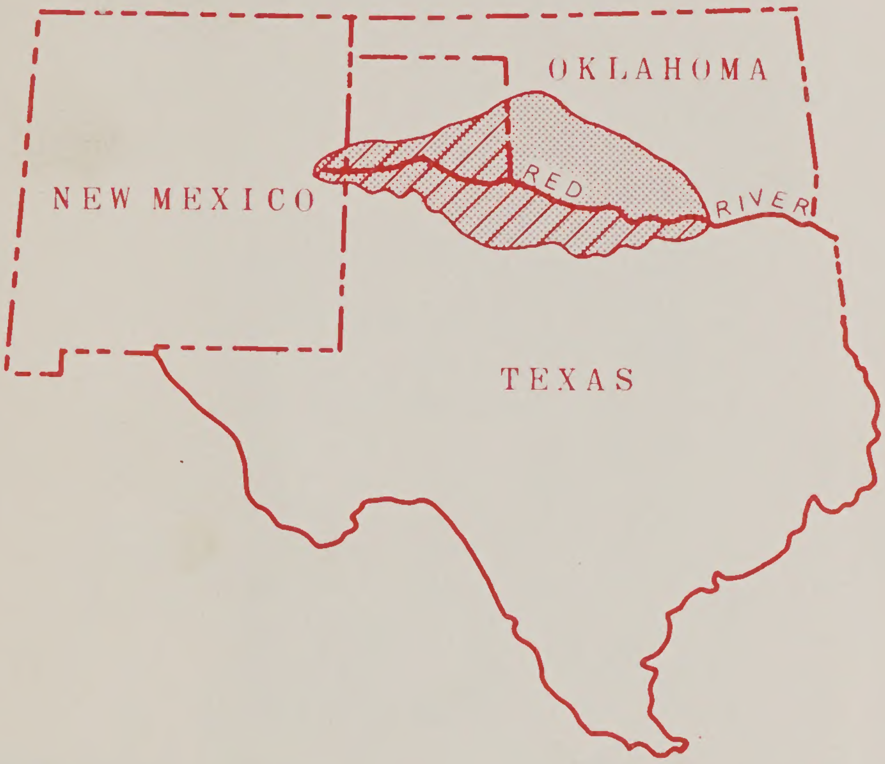
RED RIVER BASIN ABOVE DENISON DAM



COOPERATIVE RIVER BASIN SURVEY

BY
THE UNITED STATES DEPARTMENT OF AGRICULTURE
IN COOPERATION WITH
THE TEXAS WATER DEVELOPMENT BOARD
THE TEXAS STATE SOIL AND WATER CONSERVATION BOARD
INTERAGENCY COUNCIL ON NATURAL RESOURCES AND THE ENVIRONMENT
THE TEXAS WATER RIGHTS COMMISSION
AND
THE OKLAHOMA CONSERVATION COMMISSION
THE OKLAHOMA WATER RESOURCES BOARD

SEPTEMBER 1977

2451 RED RIVER BASIN ABOVE DENISON DAM

MAIN REPORT

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RED RIVER BASIN ABOVE DENISON DAM

MAIN REPORT

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SUMMARY

RED RIVER BASIN ABOVE DENISON DAM

CHAPTER 1

SUMMARY

PURPOSE

The purpose of the Red River Basin Above Denison Dam Cooperative River Basin Study is to describe the U. S. Department of Agriculture program opportunities and impacts for use in facilitating the coordinated and orderly conservation, development, utilization, and management of the water and related land resources of the basin.

The Oklahoma Conservation Commission, the Oklahoma Water Resources Board, the Texas Water Development Board, the Texas State Soil and Water Conservation Board, the Interagency Council on Natural Resources and the Environment, and Texas Water Rights Commission, in cooperation with other State and Federal agencies, are continuing long-range programs to obtain water and land resource data. This information can be used to effectively administer and assist in planning water management and land use.

The U. S. Department of Agriculture needs information about the opportunities for development of water and related land use as a basis for assisting local organizations in the development of those resources under the provisions of the Watershed Protection and Flood Prevention Act as well as other USDA programs.

AUTHORITY

The U. S. Department of Agriculture participated in this study under authority of Section 6 of the Watershed Protection and Flood Prevention Act of the 83rd Congress (Public Law 566, as amended).

DESCRIPTION OF THE BASIN

The Red River Basin Above Denison Dam extends from eastern New Mexico across the Texas Panhandle to Denison Dam on the Oklahoma-Texas boundary, Plate 1-1. It embraces an area of 25,393,890 acres. Approximately 424,600 acres are in New Mexico and the remainder are divided between Texas and Oklahoma. Elevations vary from about 4,800 feet in the headwaters area in New

Mexico to 600 feet at Denison Dam. The High Plains area west of the 101st meridian is flat to gently rolling, with numerous shallow depressions which have no drainage outlets to streams.

The area to the east is a rolling plain with well-defined drainage courses. The climate is semi-arid in the west to subhumid in the east. Average annual rainfall ranges from 16 inches in New Mexico to 39 inches at Denison Dam. Both annual and seasonal distribution of rainfall is erratic. Long periods of drought are broken by infrequent but intense rainstorms. Average annual runoff from the contributing watershed for a 52-year period is 1.95 inches or 3,515,000 acre-feet. The long summers are hot and dry, and the winters are usually relatively mild.

Agriculture, together with limited processing of agricultural products, is the predominant economic activity. About 28 percent of the total basin area is in non-irrigated cropland, six percent irrigated cropland, 48 percent in rangeland, five percent pastureland, three percent in forest land with two percent in other agricultural land. Nonagricultural uses such as urban areas, roads, Federal land, and water make up eight percent of the basin total.

Oil and gas production is important in many areas of the basin. Copper and gypsum are becoming more important to the economy in southwestern Oklahoma. The limited industrial development is concentrated principally in Wichita Falls, Texas. Other relatively large population centers are Lawton, Altus, and Ardmore, Oklahoma. Amarillo, Texas lies on the divide between the Red and Canadian watersheds and has experienced a substantial growth in the past 40 years.

The basin includes portions of seven land resource areas:

Southern High Plains	15.6 percent
Central Rolling Red Plains	60.2 percent
Central Rolling Red Prairies	10.7 percent
Cross Timbers	9.1 percent
Grand Prairie	4.1 percent
Blackland Prairie	0.2 percent
Southern Coastal Plains	0.1 percent

The total population of the basin in April 1970 was 781,474. The population of the Oklahoma portion of the basin was 429,814 (55 percent) and Texas population was 351,660 (45 percent).

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

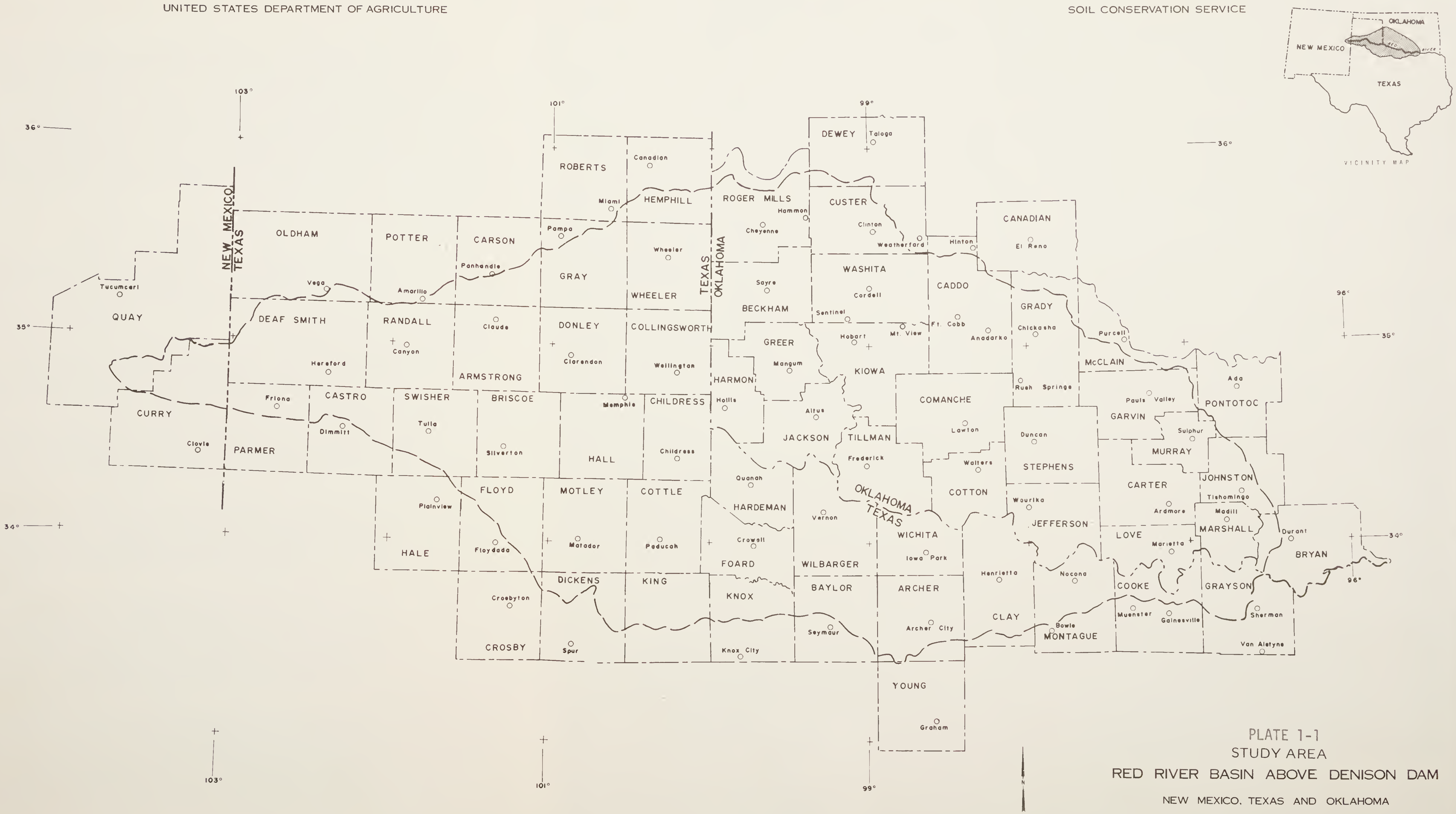


PLATE 1-1
STUDY AREA
RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA

0 20 40 60
Approximate Scale - Miles
Compiled at 1:2,109,888 (1"=33.3 miles)

Projection unknown.

FEBRUARY 1976 4-R-35412

USDA-SCS-FORT WORTH, TEXAS 1976

4-R-32372

Total population decreased slightly during the past 40 years. Rural and farm population of the basin decreased drastically during this period. Concurrently, urban population increased, particularly in the larger cities and towns. The urban growth in specific localities is traceable to new oil discoveries; to establishment of oil and gas processing plants, food processing plants, or metal fabrication units; to establishment or expansion of armed forces installations; or to development of irrigation, along with expansion of the accompanying service industries.

PROBLEMS AND OBJECTIVES

The major flooding problem to agriculture is damage to crops, pastures, and rural property. There are 1,001,900 acres of land subject to flooding. The total average annual damages are estimated at $14,140,900.

Agricultural drainage is a problem since many acres of crops and pastures are on soils where excess water is the dominant hazard or limitation in their use. There are about 145,600 acres of cropland and pastureland with impaired drainage.

A critical problem facing the basin inhabitants is a water shortage. Current water uses are at or near their maximum levels. Any significant new demands will require development of water supplies from outside the basin.

The major problem in regard to water quality is the high mineral pollution load. Natural salinity of the streams is caused by springs and seeps high in mineral content. Manmade salinity problems are caused by improper disposal of oil and gas waste waters.

Recreational problems were recognized and their extent based on the demand and supply of water, land, and facilities for selected recreational activities. These activities include camping, picnicking, swimming, golf, outdoor games, trails, and water sports. The demand for camping, swimming, and trails exceeds supply of resources.

The erosion problem in the basin can best be described in terms of land acres lost or damaged and tons of sediment delivered annually. In the study area, 265 acres of land are lost to gully erosion and 204 acres to streambank erosion annually. Scouring by flooding damages about 117,900 acres

of flood plain annually and overbank deposition of sediment on the flood plain damages 252,300 acres annually. Damage by wind erosion occurs on 638,300 acres annually.

The amount of sediment delivered to Lake Texoma from all sources in the basin is 16,364,400 tons annually.

The improper use of agricultural land is magnified by limitations associated with inherent soil properties and unfavorable climatic conditions. Over 22 million acres of agricultural land has a primary limitation in use of either erosion, wetness, shallow root zone or insufficient rainfall. These hazards affect about eight million acres of cropland, one million acres of pastureland, 12 million acres of rangeland, nearly one million acres of forest land, and about 200 thousand acres in other land uses.

Fish and wildlife problems were determined and based on the demand and supply of habitat and harvestable species. Fishing opportunities on accessible areas are adequate in Oklahoma to meet their requirements through 2020; however, in Texas their resources are sufficient only to meet the current demand. The accessible wildlife resources in Oklahoma and Texas are presently inadequate to supply the hunting demand.

Environmental problems are considered those relative to enhancement of environmental quality by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems. Problems, previously addressed, were determined and quantified to include the interrelationships of environmental factors - improvement of water quality; reduced gully, streambank and roadside erosion; reduced sediment damage; and enhancement of fish and wildlife habitat. In addition, consideration was given to the preservation of environmental features - namely, preservation of natural and scenic areas, ecological communities, archeological sites and historical sites.

NEEDS

Needs were identified for the major objectives. These needs reflect the desires as interpreted from study concerns. These needs are obtainable from a physical standpoint and also practical and reasonable. However, solutions may be limited by existing authorities and in some cases new legislation may be required. Component needs for specific components and major objectives are summarized in Table 1-1.

TABLE 1-1

Specific Components and Component Needs, Present and Projected

Red River Basin Above Denison Dam

Specific Components	Component Needs	Units	Oklahoma Present	Oklahoma 2000	Oklahoma 2020	Texas Present	Texas 2000	Texas 2020	Basin Total Present	Basin Total 2000	Basin Total 2020
ECONOMIC DEVELOPMENT											
1. Increased productivity of land for residential, agricultural, commercial, & industrial activities	Flood Reduction Agriculture	M Acres	186	186	186	8	9	8	194	194	194
	Sheet Erosion Damage Reductions	M Tons	40,907	3,841	9,004	39,033	2,359	10,334	79,936	6,201	19,838
	Wind Erosion Damage Reductions	M Acres	233	35	89	405	91	162	638	116	251
	Overbank Deposition on Flood Plains	M Acres	116	41	64	136	27	55	252	68	121
	Flood Plain Scour Damage	M Acres	64	26	41	54	12	25	117	38	65
2 Increased output of outdoor recreation opportunities	Camping	M-Days 1/	680	986	1,146	1,066	5,674	7,002	1,746	6,660	8,148
	Picnicking	M-Days 1/	165	569	884	856	14,209	21,351	1,021	14,778	22,235
	Swimming	M-Days 1/	6,782	9,426	10,832	876	22,395	46,288	7,658	32,023	57,120
	Golf	M-Days 1/	0	136	249	0	207	865	0	343	1,114
	Child's Play	M-Days 1/	917	1,391	1,612	0	309	2,455	917	1,700	4,067
	Outdoor games	M-Days 1/	742	1,113	1,302	1,254	6,225	10,659	1,996	7,338	11,961
	Trails - Combined Horseback	M-Days 1/	1,641	2,231	2,535	0	2,549	2,856	1,445	4,780	5,391
	Watersports	M-Days 1/	0	0	0	0	0	3,816	0	0	3,816
3. Increased hunting and fishing opportunities	Increased fishing act.	M-Days 1/	0	0	0	0	6,663	12,753	0	6,663	12,753
	Increased hunting act.	M-Days 1/	338	467	576	547	2,161	3,502	885	2,628	4,078
4. Increased agricultural production through irrigation	Provide additional surface water supply for irrigation	M Ac.Ft.	0	475	1,154	0	1,283	1,943	0	1,758	3,097
ENVIRONMENTAL QUALITY											
5. Improve quality aspects of water, land, and air											
a. Improve water quality	Reduce sediment to Lake Texoma	M tons	9,057	1,359	2,446	7,307	1,201	2,854	16,364	2,560	5,300
b. Improve air quality	Reduce acres supplying erosion Products to atmosphere	M acres	233	35	89	405	81	162	638	116	251
c. Reduction in non-point critical erosion	Critical erosion reductions Gully	M Gross tons	4,347	2,608	2,913	4,694	780	1,203	9,041	3,388	1,316
	Streambank	M Gross tons	2,746	1,785	2,005	2,954	585	1,374	5,700	2,470	3,379
	Roadside	M Gross tons	2,385	1,431	1,598	1,432	156	414	3,817	1,587	2,012
	Flood plain scour	M Gross tons	2,815	1,125	1,688	1,122	259	519	3,937	1,384	2,207
6. Preservation of archeological sites, historical sites, & unique areas	Protection	Number	850	850	850	1,077	1,097	1,127	1,927	1,947	1,977
	Protection	Number	20	20	20	108	112	115	128	132	135
	Protection	Acres	0	0	0	0	90	0	0	90	0
7 Increase, protect and improve fish and wildlife habitat	Fish habitat	Acres	0	0	0	0	125,725	240,624	0	125,725	240,624
	Wildlife habitat	Acres	0	1,025,273	1,824,254	3,282,540	11,347,000	21,653,000	3,282,540	12,372,273	23,477,254

1/ Thousands of activity days

Source: SCS

Table 1-2

Summary Display of Elements, Effects and Program Opportunities

Red River Basin Above Denison Dam

(2000)

Element	Economic Development Account		Environmental Quality Account	Social Well-Being Account	Program Opportunities	
	Beneficial & Adverse Effects		Beneficial & Adverse Effects	Beneficial & Adverse Effects	USDA	Other
(Quantity)	-----------$000------------					
Resource Management Systems for Erosion and Sediment Damage Reduction	Not Evaluated		1. Terrestrial wildlife habitat will benefit from accelerated land treatment associated with project implementation.	1. Household income increase (direct & external): 2.1 million	1. ACP	1. State Forestry Program
Floodwater Damage Reduction and Improved Water Management Systems					2. PL-46	2. Corps of Engineers
Channel Modification (16 miles)	366	335	2. Disrupt ecosystems on 16 miles of natural ephemeral streams.	2. Employment increased opportunities, direct & external: 228 man-years	3. PL-566 Watershed Projects	3. Housing & Urban Development
Flood Prevention (147 dams)	1,986	2,584	3. Project action will destroy 29,800 acres of riparian habitat.		4. RC&D Projects	4. Soil & Water Conservation Districts
Agricultural Water Development (28 Thous. AF)	1,122	- 1/		3. Stabilizes rural economy & rural living	5. USFS - State	5. Drainage Districts
Nonagricultural Water Development (3 Thous. AF)	165	- 1/	4. Revegetation of 390 acres of stream right-of-way with selected multi-purpose flora to enhance wildlife.	4. Increased use of natural resources at higher and better uses.	6. FHA Loans	6. Texas Parks and Wildlife Department
					7. Flood Hazard Studies	7. Bureau of Outdoor Recreation
Outdoor Recreation Facility Development	232	- 1/	5. Reduction of wintering waterfowl habitat and aquatic nursery areas by increased drainage.	5. Economic advantages not predominantly in the area of greatest need.		8. U. S. Geological Survey
Total Net	3,871	2,919				
			6. Create 16,783 surface acres of aquatic habitat.			
			7. Inundate 16,783 surface acres of medium terrestrial habitat.			
			8. Protect 199,812 acres of bottomland habitat by eliminating flooding below FP structures.			
			9. Destroy 80 acres of wetlands			

1/ Adverse Costs included in cost of Dams.

USDA PROGRAM OPPORTUNITIES

Major effects and program opportunities are summarized in Table 1-2. Data are presented for the entire basin; also, the effects are displayed for the Economic Development, Environmental Quality, and Social Well-Being accounts. Program opportunities - USDA and others - are identified.

Structural measures and facilities proposed for installation in the program by year 2020 are estimated to cost $85,390,000. Land treatment elements total $71,047,000 by year 2000 with an additional $70,062,000 estimated to be established by year 2020.

The average annual cost, consisting of project installation, operation, maintenance and replacement is $5,515,600. Average annual benefits for structural measures expected to accrue amount to $7,266,775 for an overall primary benefit-cost ratio of 1.3:1.0. Benefits from other plan elements were not evaluated.

INTRODUCTION

RED RIVER BASIN ABOVE DENISON DAM

CHAPTER 2

INTRODUCTION

This report presents the results of a study of the use and management of the water and related land resources of the Red River Basin Above Denison Dam in Texas and Oklahoma. The study was made by agencies of the U. S. Department of Agriculture with cooperation from local, State, and other Federal agencies.

In 1970 and 1971, the U. S. Department of Agriculture received requests from the Oklahoma Conservation Commission, the Oklahoma Water Resources Board, the Texas Water Development Board, the Texas State Soil and Water Conservation Board, and the Texas Water Rights Commission to participate in a cooperative study of the Red River Basin Above Denison Dam. The above agencies were sponsors of this study. The Texas State Soil and Water Conservation Board and the Oklahoma Conservation Commission are interested in the study because the problems and needs in watersheds are common to Oklahoma and Texas.

The Texas Water Rights Commission needs information on both short and long-range upstream projects so that they can effectively carry out their responsibilities in connection with the interstate compact negotiations underway for the Red River Basin Above Denison Dam. In order to protect the interest of the citizens of Texas, it is imperative that the Texas Water Rights Commission be aware of all potential developments affecting water resources. These developments include those of the USDA.

The Texas Water Development Board states that special emphasis needs to be given to present and projected land use and water requirements, as well as future water supply. The Board needs to know, in as much detail as possible, the expected future agricultural production capabilities with the projected available water supply. In order to accomplish this request, studies of the soils of the area, as well as surface geology and geomorphology of the area, need to be made in as much detail as feasible. The Board further recommended the use of the method used in past river basin studies to obtain desired coordination between the agencies involved inasmuch as those procedures proved successful.

The Oklahoma Water Resources Board is in the process of developing a State Comprehensive Water Plan, which will make an assessment of the water resource needs to meet future demands in the State and which will develop proposals for the inter-basin transfer of water from surplus areas to deficient areas to meet these needs.

The Interagency Council on Natural Resources and the Environment (ICNRE) is a sponsor of the study. The Natural Resources Section of the Texas Governor's Budget and Planning Office represents the ICNRE in the coordination of natural resource and environmental programs and issues. This study is needed to provide information for a coordinated plan for systematic multipurpose development of the natural resources of the basin and State.

AUTHORITY FOR STUDY

This study was made under the authority of Section 6 of the Watershed Protection and Flood Prevention Act (Public Law 83-566, as amended). By this act the Secretary of Agriculture is authorized to cooperate with other Federal and with State and local agencies to make investigations and surveys of the watersheds of rivers and other waterways as a basis for the development of coordinated programs.

OBJECTIVE

The objective of this study was to facilitate and coordinate the orderly conservation, development, utilization, and management of water and land resources. The patterns of water and land use to meet needs for 2000 and 2020 are described. Also specific watershed projects necessary to meet local and national social and economic needs are proposed. The consequences of alternative patterns and schedules of development were evaluated.

Information developed will be used to coordinate the USDA's water and land resource conservation and development programs with those of the Oklahoma and Texas State Water and Land Resource Plans, as well as those of other Federal agencies. Information and data obtained were compiled in such a manner that it may be used in planning action programs for water and land resource conservation, development, utilization, and management. During the course of the study, consideration was given to additional needs and desires related to the above objectives identified by the local people and their representative organizations.

NATURE OF STUDY

The study is directed to meeting current and projected study items as identified by the desires of people for economic development and environmental quality.

The study involves a series of steps starting with the identification of study items and culminating in identifying opportunities for resource development. The process involves an orderly and systematic approach to making determinations and decisions at each step. Thus decision makers are fully aware of the basic assumptions employed, data analyzed, and rationales used.

Meetings were held with sponsors, local government units, and local people to gain a better understanding of the types of problems which exist and the desires of all interests concerning economic growth and environmental preferences. These problems and desires were examined with the sponsors and local interests. They were given some definition of the objectives of economic development and environmental quality.

Studies of the land and water resource features were made. Included were selective inventories of the quantity and quality of water and land resources of the study area; an appraisal of opportunities for further use of those resources; and an examination of resource limitations for certain uses.

The USDA has responsibility for the development and conservation of land and water resources. Each decision is weighed carefully with consideration given to its effects on other resources and on the environment. Studies and investigations were limited in detail, but are compatible with the nature and magnitude of the program to which they relate. Existing data and information were used to the maximum extent possible in conducting the study.

DESCRIPTION OF STUDY AREA

The Red River Basin Above Denison Dam extends from eastern New Mexico across the Texas Panhandle and southwestern Oklahoma to Denison Dam on the Oklahoma-Texas boundary. It embraces an area of 25,393,890 acres.

The area of the Red River Basin Above Denison Dam is distributed in the three states as follows: Texas 14,225,400 acres, Oklahoma 10,743,890 acres, and New Mexico 424,600 acres.

A small portion of the basin boundary extends into New Mexico. Program opportunities for the portion of the basin which lies in New Mexico have not been included. Problems associated with flooding, sediment, irrigation, and the component needs of the basin were studied separately in Texas and Oklahoma.

Elevations vary from about 4,800 feet in the headwaters area in New Mexico to 600 feet at Denison Dam. The High Plains area west of the 101st meridian is flat to gently rolling, with numerous shallow depressions which have no drainage outlets to streams. The area to the east is a rolling plain with well defined drainage courses. The climate is semi-arid in the west to subhumid in the east. Average annual rainfall ranges from 16 inches in New Mexico to 39 inches at Denison Dam. Both annual and seasonal distribution of rainfall are erratic. Long periods of drought are broken by infrequent but intense rainstorms. Average annual runoff varies from less than one inch in the west to about seven inches in the east. The long summers are hot and dry, and the winters are usually relatively mild.

Agriculture, together with limited processing of agricultural products, is the predominant economic activity. Oil and gas production is important in many areas of the basin. Copper and gypsum are becoming more important in the economy in southwestern Oklahoma. The limited industrial development is concentrated principally in Wichita Falls, Texas. Other relatively large population centers are Lawton, Altus, and Ardmore, Oklahoma. Amarillo, Texas lies on the divide between the Red and Canadian watersheds and has experienced a substantial growth in the past 40 years.

Total population has decreased slightly during the past 40 years. Rural and farm population of the basin decreased drastically during this period. Concurrently, urban population increased, particularly in the large cities and towns. The urban growth in specific localities is traceable to new oil discoveries; to establishment of oil and gas processing plants, food processing plants, or metal fabrication units; to establishment or expansion of armed forces installations; or to development of irrigation, along with expansion of the accompanying services industries.

USDA AGENCIES' RESPONSIBILITIES

The principal participants within the U. S. Department of Agriculture were the Soil Conservation Service, the Economic Research Service, and the Forest Service. The personnel assigned to the River Basin Survey Staff by the three USDA

agencies functioned as a planning team under the guidance of the USDA Field Advisory Committee. Each agency had leadership responsibilities for designated aspects of the survey as outlined in an adopted plan of work.

Participation of the USDA agencies was carried out under assigned responsibilities and coordinated through the Field Advisory Committee as set forth in the Memorandum of Understanding between the Soil Conservation Service, Forest Service, and the Economic Research Service dated April 15, 1968 and the agreement for Coordination of Range Programs on Non-federal Forest Lands and Inventory of Forests and Rangelands between the Soil Conservation Service and Forest Service dated June 23, 1976. The Committee members maintained appropriate liaison with the administratively responsible officers of their respective services in carrying out this cooperative river basin study. The Committee also maintained liaison with the co-sponsors to assure coordination of the planning activities.

Soil Conservation Service

The Soil Conservation Service (SCS) had overall responsibilities for the administration and coordination of the USDA activities in the study, giving full recognition to responsibilities otherwise assigned. The SCS, in cooperation with other USDA agencies and the various State agencies (1) utilized, refined, and added to the data available from the Conservation Needs Inventory to determine the needs for meeting the objectives of land use and treatment; (2) collected, reviewed, and evaluated other available basic physical data pertinent to the study of water and related land resources; (3) collected physical data by field reconnaissance or surveys where existing data were inadequate; (4) compiled soil association maps and interpretations; (5) identified location and size of areas with floodwater, erosion, sediment, and related problems; (6) located and determined extent of agricultural and non-agricultural water management needs including opportunities for irrigation, drainage, municipal water, industrial water, rural domestic water, recreation, fish and wildlife, and water quality storage; (7) developed potential plans for structural control or management of water, including studies for possible storage for water management, recreation, and fish and wildlife purposes; (8) studied all significant phases of public, semi-public, and private recreation and coordinated all recreation planning with comprehensive Statewide outdoor recreation plans; (9) made watershed investigations involving engineering, hydrology, economic, geology, biology, agronomy, etc. of designated hydrologic units, and considered alternate solutions; (10) described and weighed the impact of proposed measures upon the environment; (11) exchanged data and coordinated potential projects at the field level with other agencies.

Forest Service

The Forest Service developed data, described findings, and made recommendations on forest lands, forest land needs, forest industries, and forest values required for the study. These data were obtained from SKY-LAB, State Foresters, and contacts with wood-using industries. The Forest Service (1) determined present and projected amount, character, and ownership of forest lands, volume and value of forestry production, employment and income of forest industry, and availability of markets for forest resources; (2) determined present and projected needs for forest resources and existing levels of forest protection and mangement by timber type classes; determined amount and character of erosion and hydrologic condition of forest soils, provided the SCS with present and projected runoff curve numbers for forest lands; and appraised water needs for forest-based industries and National Grasslands; (3) determined management and protection needs for forest lands, worked with the Soil Conservation Service on erosion control measures on forest lands; established priorities of forestry proposals on private and public lands; and determined impacts of all proposed projects on private and public forest lands; and (4) selected opportunities for inclusion in the short-range and long-range programs and identified the means of implementation and the coordination necessary.

Economic Research Service

The Economic Research Service, in cooperation with other USDA agencies, compiled economic data and made economic analyses relating to agriculture and its use of land and water resources. The Economic Research Service (1) described and analyzed the economy of the study area with projection of major economic forces relating to use and development of land and water resources; (2) analyzed and projected the agricultural economy, including land and water use, production and value of agricultural products, capital investments in agriculture, employment, etc.; (3) analyzed the agricultural production potential in relation to resource development opportunities; (4) analyzed the projected need for goods and services that may be produced from the land and water resources of the study area, and the availability of resources, technological advances, and alternatives for production of these products; (5) analyzed the effect of drought, floods, impaired drainage, and other agricultural water management problems as related to efficiency of production, volume and value of production, and employment and income in the survey areas as a whole; (6) analyzed the factors affecting resource development including economic and institutional factors involved in the formulation of a comprehensive study for

water and related land resource use and development; and (7) appraised the effect of the program and alternative proposals on economic activity in the agricultural and related sectors of the economy and in the overall economy of the study area.

SPONSORING AGENCIES' RESPONSIBILITIES

Texas State Soil and Water Conservation Board

The Texas State Soil and Water Conservation Board's activities are primarily directed along three lines: (1) to perform State-level administrative functions incident to the organization and operation of Soil and Water Conservation Districts; (2) to coordinate the programs of the Soil and Water Conservation Districts; and (3) to administer State responsibilities in the upstream watershed protection and flood prevention program.

In this study, the Texas State Soil and Water Conservation Board coordinated activities that involve Soil and Water Conservation Districts and local entities.

Oklahoma Water Resources Board

The Oklahoma Water Resources Board is responsible for pollution control as it applies to industry, the exceptions being waste water discharging to sanitary sewers and waste discharges from the oil and gas industry. This Board maintains a continuing water quality and quantity data program. An active program of water resources development and planning - in cooperation with other State and Federal agencies - is also maintained by this agency. In addition, there exists an extensive program for developing data on the location, quantity, and quality of ground water resources.

Texas Water Development Board

The Texas Water Development Board has certain technical and planning functions which include the preparation of a comprehensive State water plan and the continuation of technical programs related to water availability, water quality protection, reclamation, and water related services.

The Board maintained close liaison with respect to study progress, programs, assistance needs, and data needs; and abreast of resultant plans relative to the State's interest and the Board's responsibilities.

Oklahoma Conservation Commission

The Oklahoma Conservation Commission has the responsibilities of providing assistance to and the review of the conservation programs in the various districts; of coordinating, promoting, assisting, and guiding the resource conservation programs and activities of districts as they relate to each other, other special purpose districts, counties, and other local, State, and Federal public agencies.

Texas Water Rights Commission

The Texas Water Rights Commission's primary objective is "to conserve this natural resource in the greatest practicable measure for the public welfare" by the administration of water rights, the collection of data, the supervision of certain water districts, and other regulatory activities.

The Commission provided data concerning land and water resources and water rights, coordinated interest of local entities and individuals, participated in work groups, and evaluated data.

Interagency Council on Natural Resources and the Environment

The Interagency Council on Natural Resources and the Environment is a part of the Texas Governor's Budget and Planning Office. The Council was created as the focal point for all Federal, State, and local agencies to conduct State resource and environmental activities on a joint, cooperative basis.

The Council maintained a close liaison with respect to the progress of studies and activities carried out in the basin which are coorelative or parallel to this study.

ACKNOWLEDGEMENTS

The USDA Field Advisory Committee (FAC) considers it impossible to make acknowledgements to all who have aided and participated in this study. To all who collaborated in these undertakings, the FAC expresses its gratitude. Early in its work, the FAC sought to obtain data and reports already prepared pertinent to the Red River Basin Above Denison Dam. The data and reports were obtained from various sources: cities, towns, counties, river authorities, water districts, irrigation districts, drainage districts, councils of government, universities, interested groups and individuals, State agencies, and Federal agencies. Throughout the report, specific acknowledgement is made to a number of sources.

PROBLEMS AND OBJECTIVES

PROBLEMS AND OBJECTIVES

RED RIVER BASIN ABOVE DENISON DAM

CHAPTER 3

PROBLEMS AND OBJECTIVES

INTRODUCTION

The water and related land resource problems in the Red River Basin Above Denison Dam involve a number of interrelated physical, social, economic, and environmental concerns. As a result of public meetings, numerous interviews, and other public contacts, the major resource problems were identified and objectives established.

OBJECTIVES

The Red River Basin Above Denison Dam study was conducted, as much as possible, in general accordance with the "Principles and Standards for Planning Water and Related Land Resources", developed by the Water Resources Council which became effective October 25, 1973. The implementation of the Principles and Standards for this study were guided by the "USDA Procedures for Planning Water and Related Land Resources", dated March 1974.

The Principles and Standards specifies that the overall purpose of water and land resource planning be directed toward improvement in the quality of life through contributions to two major objectives:

1. National Economic Development (NED) - to enhance national economic development by increasing the value of the Nation's output of goods and services and improving national economic efficiency.

2. Environmental Quality (EQ) - to enhance environmental quality by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.

PROBLEMS

Each of the identified water and related land resource problems or study concerns must clearly be related to either the NED or the EQ major objectives. Solutions to problems related to NED reflect increases in the Nation's productive output, an

output which is partly reflected in a national product and income accounting framework designed to measure the continuing flow of goods and services into direct consumption or investment. Solutions to problems relating to EQ reflect man's abiding concern with the quality of the natural physical-biological system in which all life is sustained.

Floodwater Damages

Flooding has been a problem in the basin since the early settlers began converting the plains of native grass to cultivated fields.

Floods in the upstream watersheds generally rise and fall quickly with high velocities and high peak discharges. Damages per acre inundated from floods in the upstream reaches are usually lower than those occurring downstream due to less intensive use. Where damage occurs the ever present flood hazard may be a deterrent to more intensive use of these flood plains.

The major flood damage on agricultural land is to crops and pastures. The flood problem is severe on flood plains of high productivity and intensive use. The flood plain soils are generally more productive than the surrounding upland soils and play a major role in the farm economy. If flooding is not too frequent or severe, they are used to produce the higher value crops. Other flooding problems that directly affect agriculture include livestock losses, damages to fences, levees, and farm equipment.

Non-agricultural flood problems are primarily from damage to roads and bridges. Damages occur most frequently to county or secondary roads. Highways with asphalt or concrete surfaces are also damaged by inundation that lasts for extended periods, although some of the damage is not apparent for several months after the flood.

When flooding occurs within the corporate limits of a town or city, the adverse effects are also included with non-agricultural damages. The problems may affect either residential areas, business establishments, or both. Examples of such problems are found in a number of towns scattered throughout the study area.

Flood-producing storms can occur at any time of the year; however, they occur most frequently during the spring and fall months. Floods occur in some parts of the study area each

year. These are usually caused by local storms of high intensity. Widespread flooding is associated with storms covering large areas. The basin flood of history occurred on the Washita River in the spring of 1934 around Hammon, Oklahoma, and claimed the lives of 17 people. Livestock were drowned by the hundreds, and damage amounted to several million dollars.

There are an estimated 1,501,700 acres in the basin subject to flood damages-currently 499,800 of these acres are protected by flood control structures leaving a balance of 1,001,900 acres with no protection other than land treatment measures. Of this total 385,000 acres are in Oklahoma and 617,000 acres are in Texas.

Impaired Drainage

A drainage survey made in 1962 and updated in 1965 for Texas showed approximately 95,500 acres having a drainage problem. The problem exists on about 62,000 acres of cropland; 27,300 acres of pastureland; and 6,200 acres of forest land. The major drainage problem is the lack of adequate outlets.

TABLE 3-1

Estimated Area Subject to Flooding

Red River Basin Above Denison Dam

Land Use	Oklahoma	Texas	Basin Total
		acres	
Cropland	188,900	105,500	294,400
Pastureland	139,800	21,000	160,800
Forest Land	48,800	-	48,800
Rangeland	-	456,100	456,100
Other Lands	7,400	34,400	41,800
TOTAL	384,900	617,000	1,001,900
Average Annual Damage ($)	12,419,300	1,721,600	14,140,900

Source: SCS Data

The identification of 50,100 acres of land in Oklahoma that has impaired drainage was taken primarily from Conservation Needs Inventory (CNI), soil surveys and field investigation of the most concentrated areas. These areas are made up of soils where excess water is the dominant hazard or limitation in their use. Poor soil drainage, wetness, high water table and overflow are the criteria for identifying these soils.

The main soils having impaired drainage are the Roebuck soils with most of this being in Jefferson County. There are other soils such as Asa, Clairemont, Gracemont, and Miller which have a tendency to be wet, but these are not as concentrated as is the Roebuck. There are very narrow bands of wet soils adjacent to some of the tributaries. Some wet conditions have appeared in the Altus irrigation district due to inadequate removal of irrigation water, but this is being eliminated by on-farm drainage.

Water Shortages

The most critical problem of the basin is a water shortage. Current water demands (Table 3-2) are met primarily from ground water supplies, which are at or near their maximum use levels. Any significant new demands will require development of water resources from outside the basin.

TABLE 3-2

Current Annual Water Demands

Red River Basin Above Denison Dam

Use	Acre-Feet Oklahoma 1/	Texas 2/	Basin Total
Irrigation	356,900	2,048,700	2,405,600
Municipal	48,300	54,200	102,500
Rural	10,400	8,800	19,200
Industrial	86,800	7,500	94,300
Other	8,700	47,700	56,400
TOTAL	511,100	2,166,900	2,678,000

1/ Source: OWRB and SCS Data
2/ Source: TWDB and SCS Data

The prolonged periods of severe drought together with normally low rainfall have emphasized the need for conservation and prudent use of water throughout the basin. Water resources which can be developed are limited by both quantity and quality considerations.

Ground water is the predominant source of water for the presently irrigated agriculture in the basin. The Ogallala aquifer, which furnishes most of the water for the high plains area; and the Rush Springs Sandstone aquifer, a ground water source in southwest Oklahoma, are declining, Figure 3-1. The receding water levels indicate that the amount of irrigation which can be sustained by ground water pumping will eventually decline since the withdrawal exceeds the recharge rate.

In the High Plains area, ground water from the Ogallala Formation supplies water for municipal, industrial, and irrigation uses. Development of significant water supplies from surface sources is precluded by the low rainfall and the noncontributing character of the terrain. Thus, the potential for industrial activity and expansion of irrigation in the high plains will, in time, be limited by the cost and availability of water.

In the central rolling plains area, both ground and surface water are used. The yields of developed ground water sources have been sufficient for the rural, domestic and farmstead requirements, as well as a number of small towns. The high mineral content of most ground water makes it unsuitable for many industrial uses and undesirable for domestic and municipal uses.

An adequate water supply to meet the present and future demands of irrigated agriculture (Plate 3-1) is of the utmost importance. Irrigation production of food and fiber crops has, to a degree, resulted in a partial depletion of the ground water supplies, a situation calling for judicious use and conservation of remaining supplies.

Nearly seven million acres of irrigable land is located in the basin, of which about 1.6 million is presently irrigated, Table 3-3.

TABLE 3-3

Irrigable Land

Red River Basin Above Denison Dam

	Oklahoma	Texas	Basin Total
	acres		
Presently Irrigated	191,000	1,456,000	1,647,000
Not Irrigated	3,528,900	1,684,300	5,213,200
Total Irrigable Land	3,719,900	3,140,300	6,860,200

Source: SCS Data

Water Quality

The chemical quality of the water in streams varies dramatically throughout the basin. The major problem in regard to water quality is the high mineral content.

In general, much of the salinity of the streams is due to springs and seeps that contribute water rich in sodium and chloride to Prairie Dog Town Fork of the Red River, Washita River, North Fork Red River, Pease River, and Wichita River. The water also contains high concentrations of calcium and sulfate, which are dissolved from gypsum-bearing soils. Improper disposal of salt water produced with oil and gas also adds to the salinity problems of the water in the basin.

Inflow from other tributaries progressively reduces the salinity of the Red River downstream. However, inflows to Lake Texoma generally range between 1,000 and 2,000 parts per million (ppm) of dissolved solids.

Water released or spilled from Denison Dam generally exceeds 1,000 ppm of dissolved solids, and chloride concentrations have equaled or exceeded 250 ppm about 65 percent of the time.

As a result of intensive study of the natural salt problems by the U. S. Public Health Service and the Corps of Engineers, ten principal natural brine-emission areas have been identified in the basin. Subsequent studies of the feasibility of controlling these salt contributing sources and reducing the salinity problem in the basin led to the authorization and construction start by the Corps of Engineers.

Authorization and construction of the natural salinity alleviation projects proposed by the Corps of Engineers, together with continuing abatement of oil field pollution which has plagued parts of the basin, would result in substantial improvement in the quality of the basin's water resources. It is projected that following implementation of the authorized and proposed salinity control measures, chloride concentrations of water impounded in Lake Texoma would seldom exceed 150 ppm, and would not exceed about 110 ppm at least 50 percent of the time.

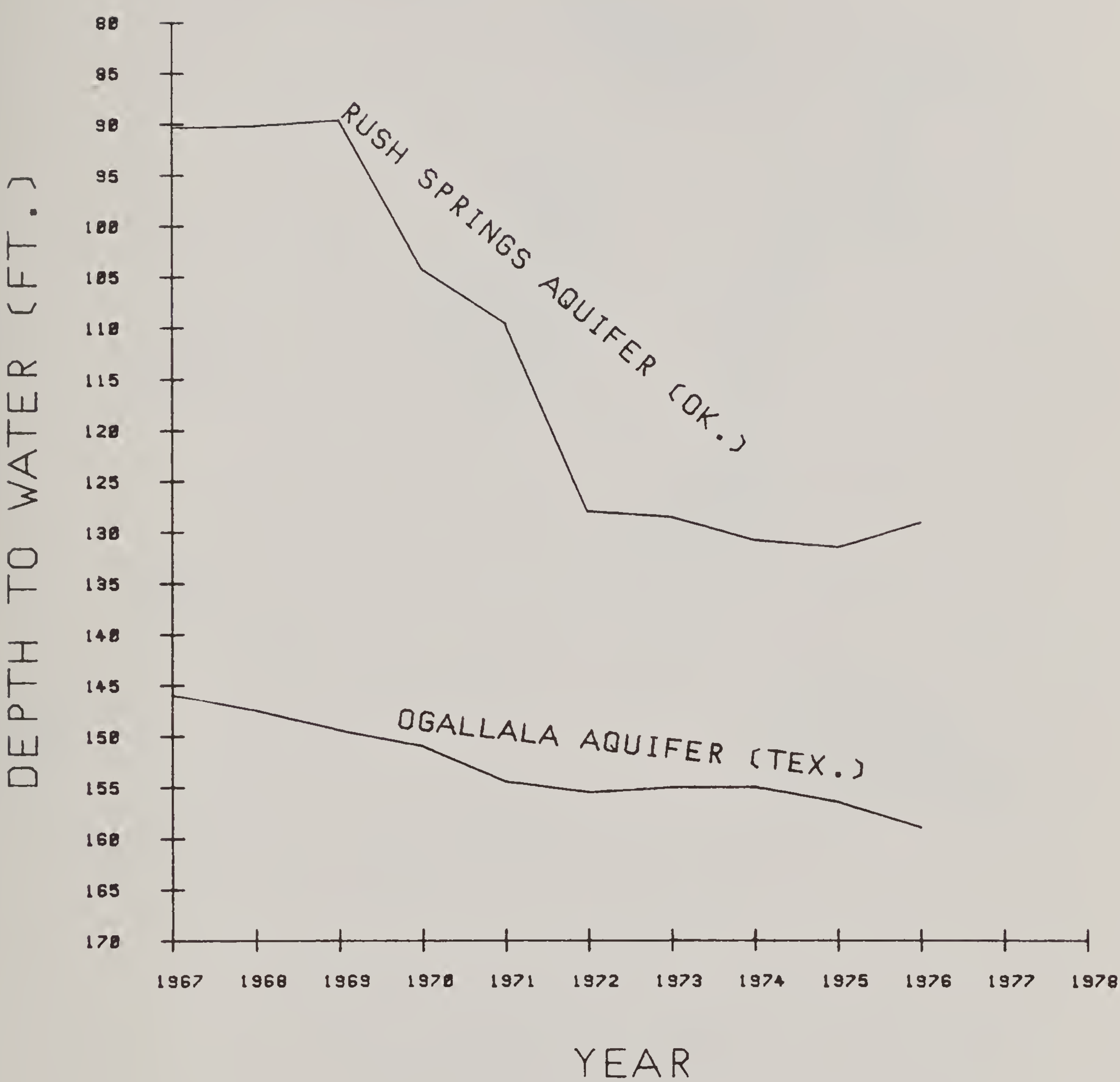
Economic Conditions

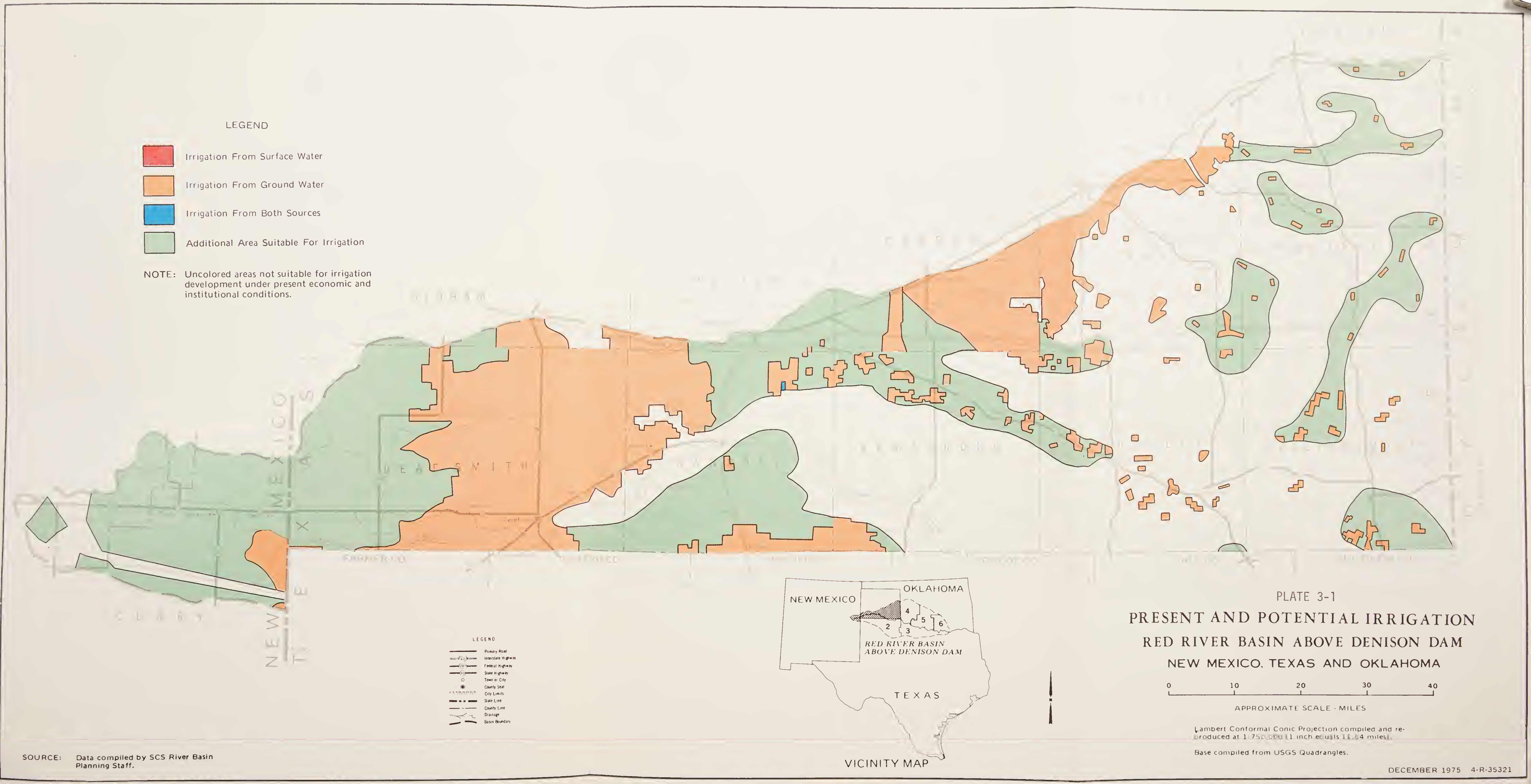
There was a slight decline in total basin population in the decade from 1960 to 1970 while the U. S. population increased 13.3 percent. During this period the pronounced movement of people from rural areas to the few urban centers continued. Over

FIGURE 3-1

Average Depth to Water

Red River Basin Above Denison Dam




LEGEND
Irrigation From Surface Water
Irrigation From Ground Water
Irrigation From Both Sources
Additional Area Suitable For Irrigation
NOTE: Uncolored areas not suitable for irrigation development under present economic and institutional conditions.
NEW MEXICO
TEXAS
DEAF SMITH
NEW MEXICO
OKLAHOMA
RED RIVER BASIN ABOVE DENISON DAM
TEXAS
VICINITY MAP
PLATE 3-1
PRESENT AND POTENTIAL IRRIGATION
RED RIVER BASIN ABOVE DENISON DAM
NEW MEXICO, TEXAS AND OKLAHOMA
0 10 20 30 40
APPROXIMATE SCALE · MILES
Base compiled from USGS Quadrangles.
SOURCE: Data compiled by SCS River Basin Planning Staff.
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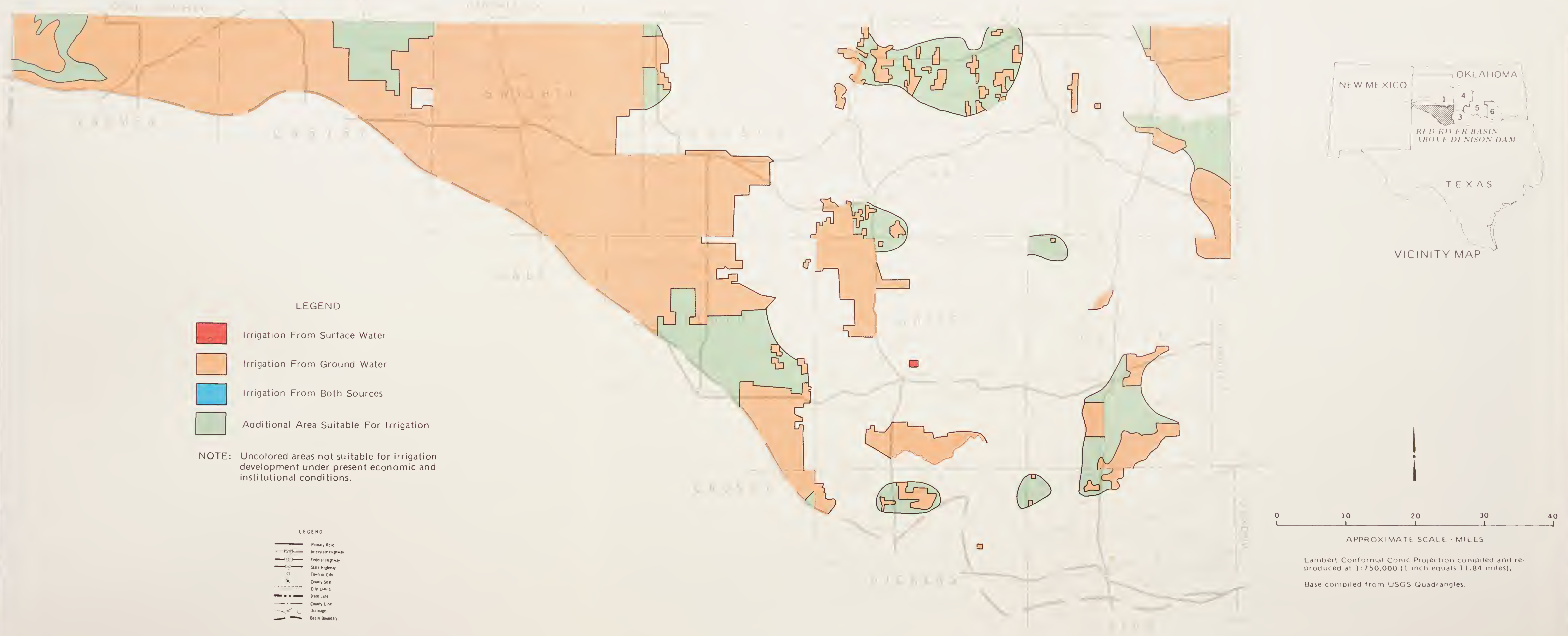

PLATE 3-1

PRESENT AND POTENTIAL IRRIGATION

RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA

SOURCE: Data compiled by SCS River Basin Planning Staff.

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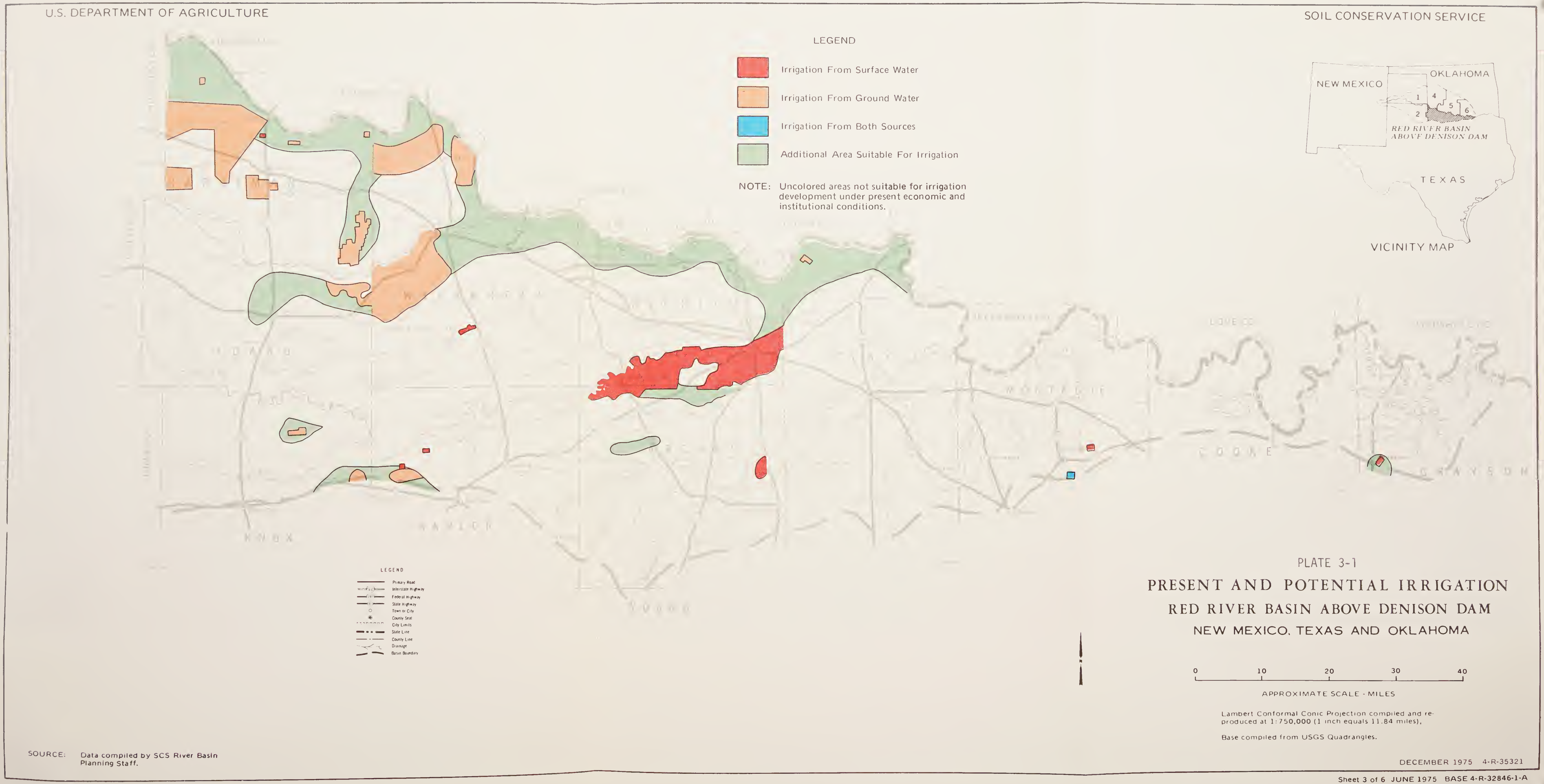
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SOIL CONSERVATION SERVICE
LEGEND
Irrigation From Surface Water
Irrigation From Ground Water
Irrigation From Both Sources
Additional Area Suitable For Irrigation
NOTE: Uncolored areas not suitable for irrigation development under present economic and institutional conditions.
NEW MEXICO
OKLAHOMA
TEXAS
RED RIVER BASIN ABOVE DENISON DAM
VICINITY MAP
LEGEND
Primary Road
Interstate Highway
Federal Highway
State Highway
Town or City
County Seat
City Limits
State Line
County Line
Drainage
Basin Boundary
PLATE 3-1
PRESENT AND POTENTIAL IRRIGATION
RED RIVER BASIN ABOVE DENISON DAM
NEW MEXICO, TEXAS AND OKLAHOMA
0 10 20 30 40
APPROXIMATE SCALE - MILES
Lambert Conformal Conic Projection compiled and reproduced at 1:750,000 (1 inch equals 11.84 miles).
Base compiled from USGS Quadrangles.
SOURCE: Data compiled by SCS River Basin Planning Staff.
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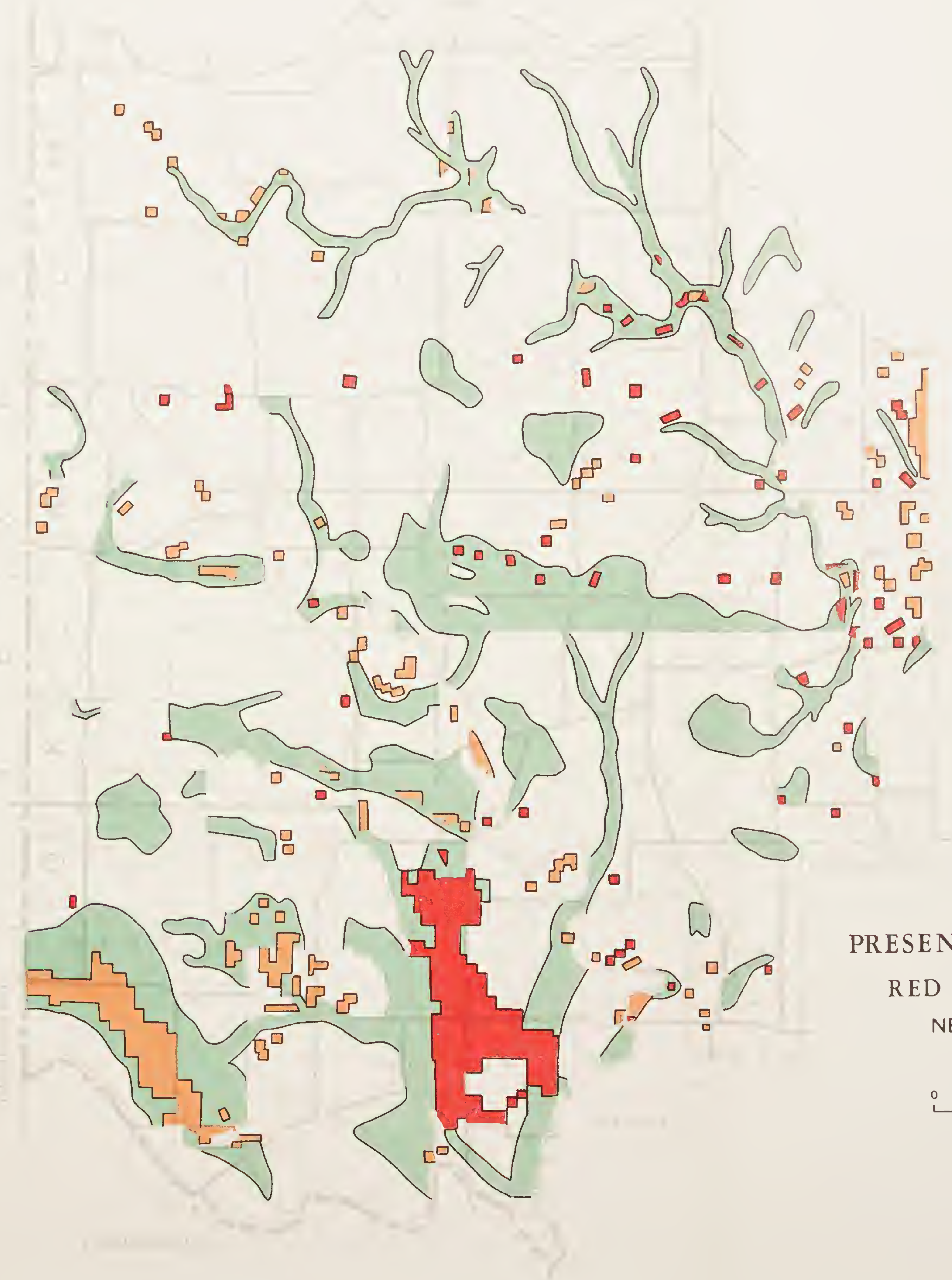
SOIL CONSERVATION SERVICE



VICINITY MAP

LEGEND

- Irrigation From Surface Water
- Irrigation From Ground Water
- Irrigation From Both Sources
- Additional Area Suitable For Irrigation

NOTE: Uncolored areas not suitable for irrigation development under present economic and institutional conditions.

LEGEND

- Primary Road
- Interstate Highway
- Federal Highway
- State Highway
- Town or City
- County Seat
- City Limits
- State Line
- County Line
- Drainage
- Basin Boundary

PLATE 3-1

PRESENT AND POTENTIAL IRRIGATION

RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA

0 10 20 30 40

APPROXIMATE SCALE - MILES

Lambert Conformal Conic Projection compiled and reproduced at 1:750,000 (1 inch equals 11.84 miles),

Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

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LEGEND

- Irrigation From Surface Water
- Irrigation From Ground Water
- Irrigation From Both Sources
- Additional Area Suitable For Irrigation

NOTE: Uncolored areas not suitable for irrigation development under present economic and institutional conditions.

VICINITY MAP

PLATE 3-1

PRESENT AND POTENTIAL IRRIGATION
RED RIVER BASIN ABOVE DENISON DAM
NEW MEXICO, TEXAS AND OKLAHOMA

0 10 20 30 40

APPROXIMATE SCALE - MILES

Lambert Conformal Conic Projection compiled and reproduced at 1:750,000 (1 inch equals 11.84 miles).

Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

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LEGEND

- Irrigation From Surface Water
- Irrigation From Ground Water
- Irrigation From Both Sources
- Additional Area Suitable For Irrigation

NOTE: Uncolored areas not suitable for irrigation development under present economic and institutional conditions.

LEGEND

- Primary Road
- Interstate Highway
- Federal Highway
- State Highway
- Town or City
- County Seat
- City Limits
- State Line
- County Line
- Drainage
- Basin Boundary

PLATE 3-1

PRESENT AND POTENTIAL IRRIGATION
RED RIVER BASIN ABOVE DENISON DAM
NEW MEXICO, TEXAS AND OKLAHOMA

0 10 20 30 40

APPROXIMATE SCALE - MILES

Lambert Conformal Conic Projection compiled and reproduced at 1:750,000 (1 inch equals 11.84 miles).

Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

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half the counties had population decreases that exceeded 20 percent. The net outmigration rate was 12.4 percent for the basin with several counties having rates in excess of 30 percent of the 1960 population. The outmigration of people from the basin is partly due to the lack of job opportunities. According to the U. S. Census classification, 15.6 percent of the families in the basin have an income below the poverty level and in over one-third of the counties this percentage exceeds 20 percent.

Recently there has been a shift from the production of agricultural products requiring a relatively large amount of hand labor to those requiring much less hand labor. Also, technological improvements and the substitution of machinery for manpower during the past 20 years has made it possible to produce more agricultural products with fewer employees. With fewer employees needed by the basin agricultural industry, there is consequently, less demand for the service-producing industries such as wholesale and retail trade, professional, and business services, etc.

The gradual decline of employment in the basic industry and a subsequent decline of employment in service industries has diminished the economic base so that educational institutions, health centers, and cultural and social conditions have not kept pace with other areas.

The fact that this basin has little commercial forest land has led to three related problems which tend to debilitate the few operable commercial forest stands even further: (1) a generally small and inefficient wood-using industry, (2) little information as to what the forest types are or where they occur, and (3) little management assistance available either for forest landowners or industry.

Forest evaluation and management efforts receive little attention because most landowners do not know the present or potential values of their forests.

Recreational Shortages

The Red River Basin Above Denison Dam lacks adequate recreational development. Part of this shortage is due to a lack of recreational expansion and part is because of the large increase in demand. Characterizing this demand increase is (1) an increase in leisure time; (2) an increase in income which introduces a larger clientele to Federal, State, and privately-owned facilities; (3) basin's central location nationally; (4) greater mobility and; (5) general changes in the attitudes of people toward outdoor recreation.

The demands for recreational facilities vary within the basin. Spacial distribution of recreational resources are unevenly distributed in the basin. For example, the eastern portion of the basin with Lake Texoma and other lakes indicates a surplus of water-based sports activities whereas the western portion has a great demand for these types of activities. Even though there appears to be an excess of some activities, this may or may not be the case for specific areas in the basin.

Table 3-4 shows there is currently an approximate basin shortage of 3,156 camping sites, 144,900 square yards of swimming areas, 480 miles of horseback trails, and 334 miles of combined trails. The most pressing urban recreational demand is for swimming areas.

The major problem affecting recreational shortages is the lack of land dedicated to recreational development, especially in and near populated areas. Recreation has not been able to compete successfully with other land uses. This situation is complicated by the lack of incentives which could encourage the dedication of land for open space and recreational areas.

Erosion

Erosion by water and wind in the basin causes extensive losses in the productive capacity of the soil. Table 3-5 shows gross erosion by sources.

Sheet erosion causes the largest amount of soil movement (79,935,100 tons) annually (Table 3-5) and also yields the largest amount of sediment to the mouths of individual watersheds (16,411,800 tons) annually, Table 3-6. Areas of sheet erosion exceeding the rate considered the maximum allowable (5 tons per acre annually) exist within the basin, particularly on the sandy soils.

Erosion rates are influenced by vegetative ground cover as well as soil. The sandy soils of the Cross Timbers Land Resource Area are highly susceptible to gully erosion and the sediment produced from these sources and delivered to Lake Texoma exceeds that from sheet erosion.

Table 3-6 shows the estimated acres lost annually to erosion and sediment yield sources.

Gully erosion is high in the Cross Timbers Land Resource Area and on formerly cultivated land that has reverted back to rangeland in all other land resource areas. It is moderately high in the Central Rolling Red Plains Land Resource Area. Streambank erosion is moderately severe in in areas of deep sandy soils found in

TABLE 3-4

Supply and Demand for Selected Outdoor Recreational Activities

Red River Basin Above Denison Dam

Activity 1/	Units	Oklahoma 2/		Texas 3/		Basin Total	
		Supply	Demand	Supply	Demand	Supply	Demand
Camping	Sites	1,458	2,591	1,684	3,707	3,142	6,298
Picnicking	Sites	3,611	3,742	1,335	2,120	4,946	5,862
Swimming	1000 sq.yds.	26.4	152	52.7	72	79.1	224
Golf	Holes	513	333	198	142	711	475
Outdoor games	Acres	742	924	944	229	1,686	1,153
Combined Trails	Miles	58	168	44	268	102	436
Horseback Trails	Miles	41	527	29	23	70	550
Watersports	Surface Acres	65,400	32,010	88,614	16,149	154,014	48,159

1/ Definitions for these activities are shown in Chapter 4
2/ Source: SCORP
3/ Source: TORP

TABLE 3-5

Gross Erosion by All Sources

Red River Basin Above Denison Dam

Source	Oklahoma	Texas	Basin Total
	-----------	Tons/Year	-----------
Sheet			
Cropland			
(Dry)	23,946,200	19,650,400	43,596,600
(Irrigated)	1,260,300	1,204,300	2,464,600
Pastureland	1,691,200	170,700	1,861,900
Rangeland	12,226,900	17,742,100	29,969,000
Forest Land (Grazed)	1,511,000	213,000	1,724,000
Other Land	1,449,200	52,000	1,501,200
Sub-total Sheet Erosion	42,084,800	39,032,500	81,117,300
Gully	4,347,400	4,693,800	9,041,200
Streambank	2,746,400	2,953,600	5,700,000
Roadside	2,385,400	1,432,400	3,817,800
Flood Plain Scour	2,812,500	1,122,000	3,934,500
Grand Total	54,376,500	49,234,300	103,610,800

Source: SCS Data

TABLE 3-6

Acres Lost and Damaged by Erosion and Sediment Yield

Red River Basin Above Denison Dam

Item	Oklahoma	Texas	Basin Total
Sediment Yield by Sources [1]	----------tons/yr.----------		
Sheet erosion [2]	7,771,500	8,640,300	16,411,800
Gully erosion	1,235,600	4,224,400	5,460,000
Streambank erosion	1,098,600	2,658,200	3,756,800
Roadside erosion	596,300	1,289,200	1,885,500
Flood plain scour	984,400	1,009,800	1,994,200
Acres Lost by Source	----------acres/yr.----------		
Gully erosion	86	179	265
Streambank erosion	66	138	204
Acres Damaged by Source	----------acres/yr.----------		
Scour	63,800	54,100	117,900
Wind	233,400	404,900	638,300
Overbank deposition	115,900	136,400	252,300
	----------tons/yr.----------		
Sediment Delivered to Lake Texoma	9,057,200	7,307,200	16,364,400

1/ To mouths of watersheds
2/ Includes grazed forest land: TX - 40,900 tons per year and OK = 166,800 tons per year

Source: SCS Data

many parts of the basin, and moderate in the Central Rolling Red Plains Land Resource Area.

Dirt roads, roadside banks, and gullies produce a moderate amount of erosion in the cross timbers areas, and in those areas where the roads have been located over steep slopes and deep soil profiles. Flood plain scour is moderate on many of the flood plains throughout the basin. It is more severe in cropland areas that flood frequently. There are 117,900 acres damaged annually by scouring of the flood plain.

Wind erosion is a serious problem over the western portion of the basin. About 638,300 acres of land are damaged annually to some degree. The sand and silt size particles are driven across fields damaging plants and piling up along fence rows and roads. Plate 3-2 shows eight categories of wind erosion susceptibility based on rainfall and soil types.

Table 3-7 shows the acres in each category of susceptibility. During periods of normal rainfall, most of this acreage suffers only minor amounts of wind erosion; however, when droughts occur much of this acreage has severe losses.

TABLE 3-7

Wind Erosion Susceptibility

Red River Basin Above Denison Dam

Susceptibility	Oklahoma	Texas	Basin Total
	acres		
Extreme	1,009,300	2,579,600	3,588,900
Very High	360,700	0	360,700
High	199,200	947,600	1,146,800
Moderately High	0	545,800	545,800
Moderate	1,775,500	3,272,300	5,047,800
Moderately Low	1,168,100	1,813,900	2,982,000
Very Low	1,728,900	0	1,728,900
None	4,458,300	5,066,200	9,524,500

Source: SCS Data

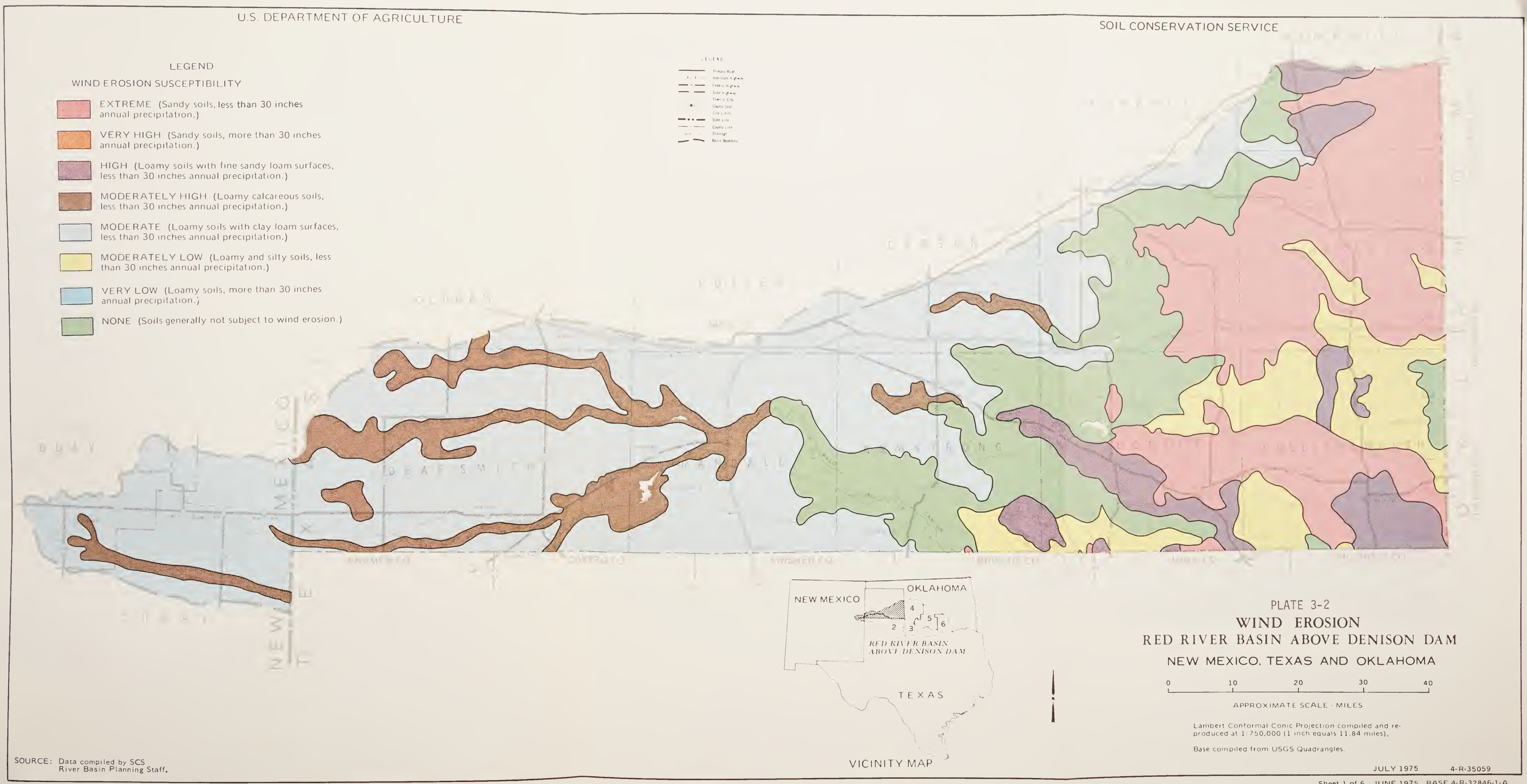

PLATE 3-2
WIND EROSION
RED RIVER BASIN ABOVE DENISON DAM
NEW MEXICO, TEXAS AND OKLAHOMA

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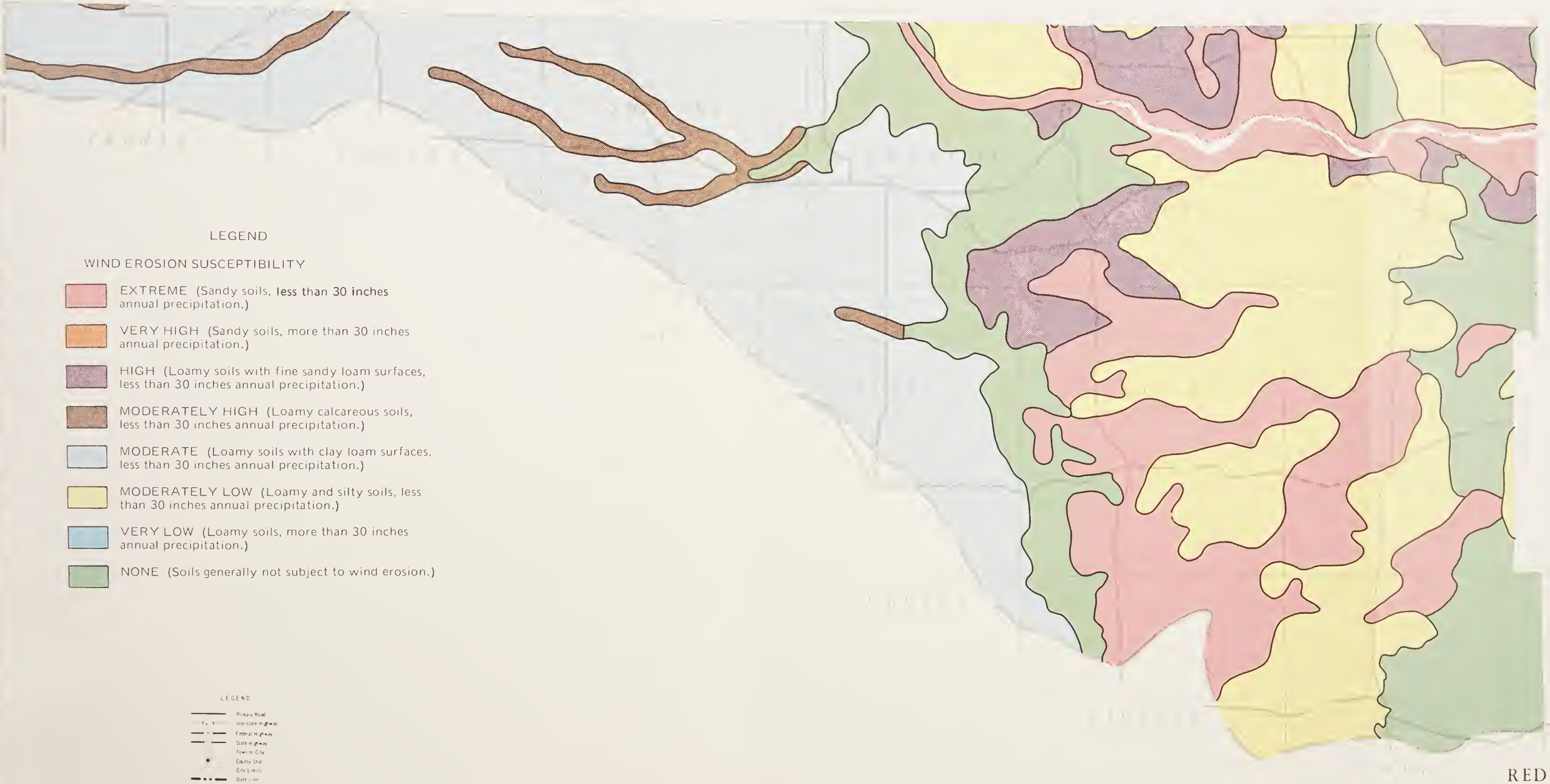

VICINITY MAP

LEGEND

WIND EROSION SUSCEPTIBILITY

- EXTREME (Sandy soils, less than 30 inches annual precipitation.)
- VERY HIGH (Sandy soils, more than 30 inches annual precipitation.)
- HIGH (Loamy soils with fine sandy loam surfaces, less than 30 inches annual precipitation.)
- MODERATELY HIGH (Loamy calcareous soils, less than 30 inches annual precipitation.)
- MODERATE (Loamy soils with clay loam surfaces, less than 30 inches annual precipitation.)
- MODERATELY LOW (Loamy and silty soils, less than 30 inches annual precipitation.)
- VERY LOW (Loamy soils, more than 30 inches annual precipitation.)
- NONE (Soils generally not subject to wind erosion.)

PLATE 3-2

WIND EROSION

RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA

0 10 20 30 40

APPROXIMATE SCALE - MILES

Lambert Conformal Conic Projection compiled and reproduced at 1:750,000 (1 inch equals 11.84 miles).

Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

JULY 1975 4-R-35059

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

PLATE 3-2

WIND EROSION
RED RIVER BASIN ABOVE DENISON DAM
NEW MEXICO, TEXAS AND OKLAHOMA

Lambert Conformal Conic Projection compiled and reproduced at 1:750,000 (1 inch equals 11.84 miles).

Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

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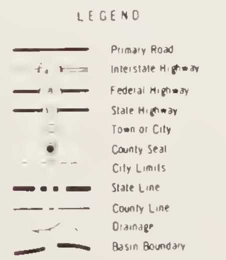
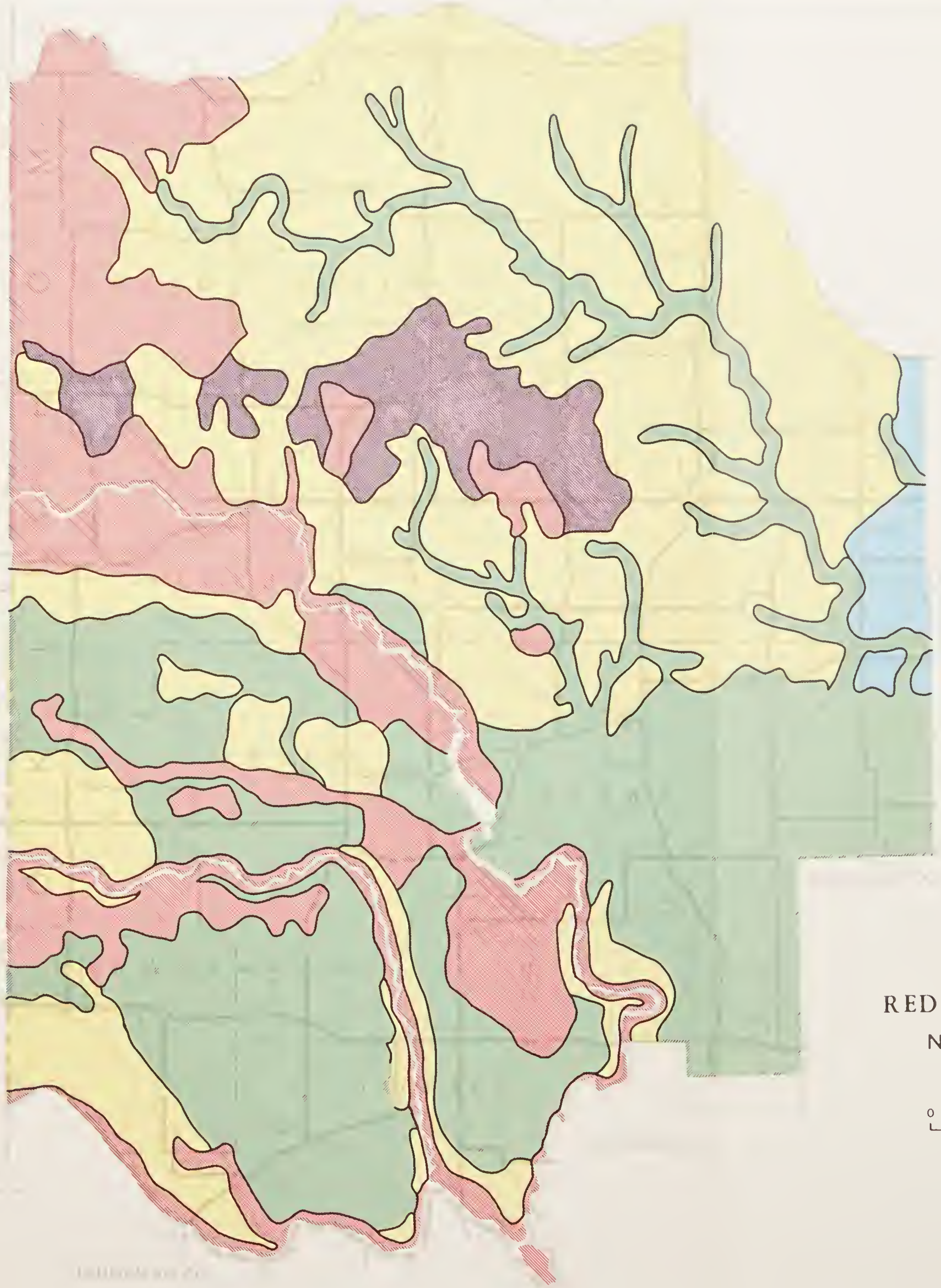
LEGEND

WIND EROSION SUSCEPTIBILITY

- EXTREME (Sandy soils, less than 30 inches annual precipitation.)
- VERY HIGH (Sandy soils, more than 30 inches annual precipitation.)
- HIGH (Loamy soils with fine sandy loam surfaces, less than 30 inches annual precipitation.)
- MODERATELY HIGH (Loamy calcareous soils, less than 30 inches annual precipitation.)
- MODERATELY LOW (Loamy and silty soils, less than 30 inches annual precipitation.)
- VERY LOW (Loamy soils, more than 30 inches annual precipitation.)
- NONE (Soils generally not subject to wind erosion.)





VICINITY MAP

PLATE 3-2

WIND EROSION
RED RIVER BASIN ABOVE DENISON DAM
NEW MEXICO, TEXAS AND OKLAHOMA

0 10 20 30 40

APPROXIMATE SCALE - MILES

Lambert Conformal Conic Projection compiled and reproduced at 1:750,000 (1 inch equals 11.84 miles).

Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

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USDA-SCS-FORT WORTH TEXAS 1976

Sheet 4 of 6 JUNE 1975 BASE 4-R-32846-1-A

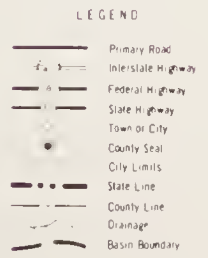
U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

LEGEND

WIND EROSION SUSCEPTIBILITY

- EXTREME (Sandy soils, less than 30 inches annual precipitation.)
- VERY HIGH (Sandy soils, more than 30 inches annual precipitation.)
- HIGH (Loamy soils with fine sandy loam surfaces, less than 30 inches annual precipitation.)
- MODERATELY HIGH (Loamy calcareous soils, less than 30 inches annual precipitation.)
- MODERATELY LOW (Loamy and silty soils, less than 30 inches annual precipitation.)
- LOW (Loamy soils with fine sandy loam surfaces, more than 30 inches annual precipitation.)
- VERY LOW (Loamy soils, more than 30 inches annual precipitation.)
- NONE (Soils generally not subject to wind erosion.)



VICINITY MAP

PLATE 3-2

WIND EROSION
RED RIVER BASIN ABOVE DENISON DAM
NEW MEXICO, TEXAS AND OKLAHOMA

0 10 20 30 40

APPROXIMATE SCALE - MILES

Lambert Conformal Conic Projection compiled and reproduced at 1:750,000 (1 inch equals 11.84 miles).

Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

JULY 1975 4-R-35059

USDA-SCS-FORT WORTH, TEXAS 1976

Sheet 5 of 6 JUNE 1975 BASE 4-R-32846-1-A

LEGEND

WIND EROSION SUSCEPTIBILITY

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- VERY LOW (Loamy soils, more than 30 inches annual precipitation.)
- NONE (Soils generally not subject to wind erosion.)

LEGEND

- Primary Road
- Interstate Highway
- Federal Highway
- State Highway
- Town or City
- County Seat
- City Limits
- State Line
- County Line
- Drainage
- Basin Boundary

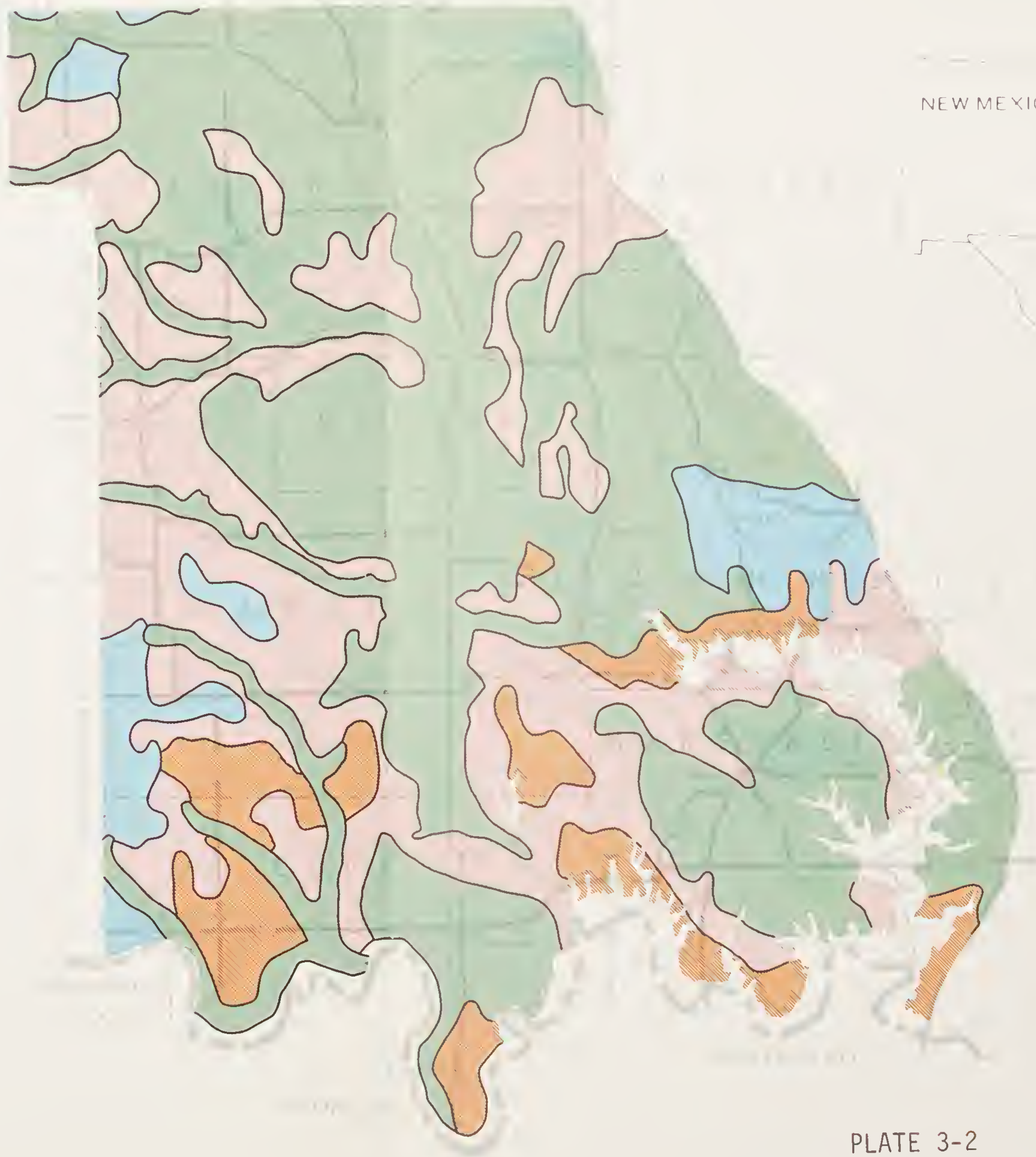


PLATE 3-2

WIND EROSION
RED RIVER BASIN ABOVE DENISON DAM
NEW MEXICO, TEXAS AND OKLAHOMA

0 10 20 30 40

APPROXIMATE SCALE · MILES

Lambert Conformal Conic Projection compiled and reproduced at 1:750,000 (1 inch equals 11.84 miles).

Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

JULY 1975 4-R-35059

USDA-SCS-FORT WORTH TEXAS 1976

The estimated average annual tons of soil moved in each category of susceptibility are shown in Table 3-8.

TABLE 3-8

Average Annual Gross Tons Lost from Wind Erosion

Red River Basin Above Denison Dam

Susceptibility	Oklahoma	Texas	Basin Total
	----------	tons/yr.	----------
Extreme	2,018,700	4,936,800	6,955,500
Very High	541,000	0	541,000
High	53,800	211,500	265,300
Moderately High	0	69,200	69,200
Moderate	230,800	447,000	677,800
Moderately Low	128,500	197,200	325,700
Very Low	0	0	0
None	0	0	0

Source: SCS Data

Erosion from forest land is minimal when compared to other sources. This does not minimize the need for treatment, however. Treatment will be aimed at putting disturbed land back to in its natural or near natural state as quickly as possible after disturbance.

Erosion and sedimentation are two phenomena which follow any land disturbance. Where forest land is concerned, erosion and sedimentation follow such activities as: grazing, logging, burning, and timber management operations. The only disturbance common enough to measure was that of grazing. Although no forest activity produced erosion rates exceeding the soil loss tolerance of 5 tons per acre per year, rates approaching that occurred in the Central Rolling Red Plains and Cross Timbers Land Resource Areas. Grazing in both these LRA's should be undertaken with care.

Sedimentation

Table 3-9 shows the average annual amount of total sediment delivered annually to the mouths of all watersheds within the basins. This is estimated to be 29,508,300 tons annually of which about 16,364,400 tons will reach Lake Texoma. This is equivalent to about 9,200 acre-feet annually in place within the reservoir. It is estimated that average annual sediment deposition on the flood plains within the basin amounts to about 252,300 acres annually.

TABLE 3-9

Sediment Yield

Red River Basin Above Denison Dam

Sediment	Unit	Oklahoma	Texas	Basin Total
To Watershed Mouths	Tons/Yr.	11,686,400	17,821,900	29,508,300
Reaching Lake Texoma	Tons/Yr.	9,057,200	7,307,200	16,364,400
Deposited in Lake Texoma	Ac.Ft./Yr.	5,200	4,000	9,200
Deposited on Flood Plains	Ac./Yr.	115,900	136,400	252,300

Source: SCS Data

Land Use and Management

Improper use of our land resources is a problem of tremendous importance in the basin. Although progress toward alleviating this problem has been made over the years, conservation is a dynamic problem requiring constant watchfulness to protect limited resources.

The basin's problems require wise conservation, development, utilization, and management of water and related land resources. The need to reduce the resource-based problems is magnified by the increased competition for resources, projected demand for food, fiber, and related products, and the recent interest in improving environmental conditions.

Improper land use and management, such as buildings constructed in flood plains and on soils poorly suited for construction purposes, has resulted in costly flood damages, drainage and health problems, structural failures, and a host of other problems in land development. Soil erosion, loss of plant cover, and impairment of natural beauty have resulted because the natural characteristics of the land and man's use of it are in conflict. Many water related land resource problems can be minimized, and some can be avoided by wise use of land resources.

Excess water becomes a problem when it interferes with land preparation, tillage, plant development, and harvesting operations in the field of agriculture. These problems contribute to reductions in crop yields, increased production costs, and lower quality products.

Some acreages suited only for native vegetation are still devoted to cropland. This tends to compound the sheet erosion problem while offering only nominal returns to the producer even in average years.

Rangeland and pastureland, when properly managed and maintained, have little erosion. Most of the excessive erosion problems on range and pastureland result from inadequate grass cover, overgrazing, improper fertilization, lack of weed and brush control, and related management practices.

Soil erosion by wind is also a serious problem. This problem provides dual hazards; a dwindling resource base due to decreased soil productivity; and a reduction in environmental quality associated with increased concentration of particles in the air. The major cause of wind erosion is the lack of vegetation upon the land.

Urbanization is a basin problem requiring thoughtful land use planning. The facts concerning urbanization are: (1) most of the land urbanized was previously cropland with grassland contributing a small percentage and, (2) There are areas brought into urban development with little regard for appropriate conservation planning. On countless areas, developers strip vegetation from building sites without regard to time lapses between development and actual construction. The result of this action is countless tons of topsoil washed and blown away. This damage to the environment is a tremendous price for interim advertising that an area is open for development. Often some of the most productive agricultural areas are chosen for development and the ensuing land abuse.

The problems mentioned are only a few involving misuse and abuse of our land resource. Open dumps are commonplace, as well as acres and acres of salvage yards. Residential areas are placed on soils incapable of absorbing sewage, and feedlots are located on areas adjacent to streams. One of the greatest needs in the basin is to develop patterns of good land use providing food for families, contours for conservation, woodland for timber and wildlife, and spacious places to live.

Fish and Wildlife

The principal concerns associated with fish and wildlife management are loss and modification of habitat, pollution, needs for improved management to increase wildlife populations on existing habitat, inadequate harvests due to limited access, and lack of incentives for private landowners to emphasize wildlife management in their agricultural operations.

A general trend to intensify agricultural production has created several situations unfavorable for sustaining wildlife populations. Some of these are (1) heavy use of native grass rangelands with associated mechanical or chemical removal of woody plants, (2) clearing of woody vegetation, especially along the creek bottoms, and conversion to cropland or improved pasture, and (3) clearing of woody cover on lands where an erosion hazard exists resulting in an immediate loss of habitat and increased sediment loads in the drainage ways and streams.

Preservation of Archeological and Historical Resources

The basin area has been significant in historical events. There is increased public interest in the basin and the Nation for the preservation of archeological and historical sites. Thus far in the study area 2,055 sites have been recorded of which 1,927 are archeological and 128 are historical, Table 3-10. Many other sites are expected to be found in the future and should be asse sed.

TABLE 3-10

Recorded Archeological and Historical Sites

Red River Basin Above Denison Dam

Sites	Oklahoma 1/	Texas 2/	Basin Total
	------------	numbers	------------
Archeological	850	1,077	1,927
Historical	20	108	128
TOTAL	870	1,185	2,055

Source: 1/ Archeological Perspective of Oklahoma
2/ Archeological and Historical Special Report - Texas

SPECIFIC COMPONENTS

The problems or study concerns were translated into specific components of the NED and EQ objectives. Specific components refer to the desired goals for goods and services, and environmental conditions being sought as contributions to ED and EQ. The components are expressed in terms of outputs (beneficial effects); never in terms of inputs to the plan. Just as the problems were identified by public involvement, specific components are publicly expressed as desires and preferences.

First Level (Desires)

The first level of specific components are directly related to the NED objective as to kind of actual outputs of goods and services desired, and directly expressed to the EQ objective as the creation, management, or preservation of the natural physical-biological system.

Second Level (Preferences)

The second level of specific components for the NED objective is the translation of the first level for goods and services into specific needs for water and land resources.

The second level of specific components for EQ objective is expressed directly in terms of preferred environmental conditions.

Table 3-11 shows the relationship between objectives, problems, and specific components.

TABLE 3-11
Objectives and Problems
Red River Basin Above Denison Dam

PRIMARY OBJECTIVE	PROBLEMS (PUBLIC CONCERNS)	SPECIFIC COMPONENTS OF THE OBJECTIVES: FIRST LEVEL (DESIRES)	SPECIFIC COMPONENTS OF THE OBJECTIVES: SECOND LEVEL (PREFERENCES)
NATIONAL ECONOMIC DEVELOPMENT	1. (Floodwater Damage) a. Frequent Flood Damage	Increase or More Efficient Output of Food and Fiber	Reduce Floodwater and Related Damages
		Improve Living and Working Conditions	Reduce Flood Hazard
	2. (Drainage) Frequent Crop Damage Due to Poor Drainage	Increased or More Efficient Output of Food and Fiber	Provision to Control Excessive Soil Moisture
	3. (Water Supply) Limited Supply of Water for Multi-uses	Increase and/or Stabilize Output of Goods and Services	Opportunities for More Efficient Use of Existing Water Supplies and Developing Additional Supplies: a. Municipal & Industrial b. Irrigation c. Recreation d. Rural Dams e. Others f. Water Conservation for More Efficient Use of Rainfall
	4. (Economic Conditions) Inadequate Employment Opportunities and Low Income	Decrease Out Migration and Underemployment and Un-Employment and Increase Personal Income	Improve Land and Water Resource Conditions Resulting in Better Job Opportunities
	5. (Recreation) Limited Recreational Opportunities	Increase or Improve Recreational Services	Provision for Water and Related Recreation Opportunities

TABLE 3-11
Objectives and Problems
Red River Basin Above Denison Dam
(cont'd)

PRIMARY OBJECTIVE	PROBLEMS (PUBLIC CONCERNS)	SPECIFIC COMPONENTS OF THE OBJECTIVES	
		FIRST LEVEL (DESIRES)	SECOND LEVEL (PREFERENCES)
NATIONAL ECONOMIC DEVELOPMENT (Continued)	6. (Erosion and Sediment) Damages from Erosion and Sedimentation	a. Increased Output of Food and Fiber b. Maintain Productivity of the Land c. Reduce Sediment in Streams, Rivers, Lakes, etc.	a. Provisions for Reducing Erosion and Sediment b. Water Conservation for More Efficient Use of Rainfall
	7. (Land Use Management) Improper Land Use	a. Increased Output of Food and Fiber b. Maintain and Improve Productivity and Use of the Land	a. Improve Land Use Management b. Water Conservation for More Efficient Use of Rainfall
ENVIRONMENTAL QUALITY	1. (Water Quality) Limited Supply of Good Quality Water	Improve Water Quality for Biological Resources and Aesthetic Values	Identify Opportunities to Improve Water Quality
	2. (Recreation) Limited Recreational Opportunities	Increase or Improve Recreational Services	Provision for Water and Land Related Recreation Opportunities.
	3. (Fish and Wildlife) Limited and Declining Fish and Wildlife Habitat	Increase, Protect and Improve Fish and Wildlife Habitat	Opportunities to Increase, Protect, and Improve Fish and Wildlife Habitat
	4. (Erosion and Sedimentation) Damages from Sediment and Erosion	Improve Quality of Land, Air and Water	Provisions for Reducing Erosion and Sediment
	5. (Environmental Conditions) Damages to Archeological and Historical Values and Areas of Natural Beauty	Conserve and Preserve: a. Areas of Natural Beauty b. Archeological and Historical Sites	a. Preserve Areas of Natural Beauty b. Protect Archeological and Historical Resources

Source: River Basin Staff, USDA

RESOURCE BASE

RED RIVER BASIN ABOVE DENISON DAM

CHAPTER 4

RESOURCE BASE

LOCATION

The Red River Basin Above Denison Dam extends from eastern New Mexico across the Texas Panhandle and southwestern Oklahoma to Denison Dam on the Oklahoma-Texas boundary. The basin is bounded on the south by the Brazos and Trinity rivers basins, and on the north by the Canadian River Basin. The basin embraces an area of 25,393,890 acres; however, the study area only includes 10,743,890 acres in Oklahoma and 14,225,400 acres in Texas with the remaining 424,600 acres outside the study area in New Mexico. Total study area is 24,969,290 acres.

CLIMATE

The basin is located at the southeastern edge of the Southern Great Plains and provides a warm continental climate of generally mild winters and long hot summers. Periods of unsettled weather or severe storm conditions develop over the basin when the prevailing warm, moisture-laden air arriving from the Gulf of Mexico conflicts with the cool and drier air arriving from the West Coast or Canada.

The winters are relatively mild and of short duration. Strong outbreaks of cold and snow conditions last only a few days. Spring is the wettest season and also the most variable. Spring weather is marked by high winds, high intensity rainfall and severe thunderstorms, which are sometimes accompanied by hail and tornadoes. The long warm summers provide many hot days which are eased by the periodic presence of relatively low humidity, prevailing winds and rainshowers or thunderstorms.

Mean annual temperature of the basin varies from 56°F in the northwest section of the basin to 65°F in the vicinity of Lake Texoma, Plate 4-1.

The dates of the first killing frost in the fall range from October 18 to November 3, while the dates of the last freeze in the spring ranges from April 3 to April 15. The average length of the growing season varies from 198 days in the northwest portion of the basin to 226 days in the southeast section.

The average annual rainfall varies from 16 inches in the western section to 39 inches in the east, Plate 4-2.

The average annual snowfall varies from four inches to near 12 inches across the basin, depending upon location.

The average annual lake evaporation varies from 50 inches in the east to 65 inches in the west.

GEOLOGY

The geology map, Plate 4-3, shows the distribution of the various formations which crop out throughout the basin. In age they range from recent Alluvium to Pre-Cambrian.

In the Quaternary Period, recent alluvium deposits are found along the flood plains of the major watercourses and consist mainly of silts and sands. Older terrace deposits occupy large areas and are made up by clays, silts, sands, and gravels.

During the Tertiary Period, the Ogallala Formation was deposited as a huge outwash fan. This formation is found in all three states and ranges from clays to coarse gravels.

The Cretaceous Period rocks are marine deposits, contain many fossils, and consist of various formations of shale, sandstone, and limestone.

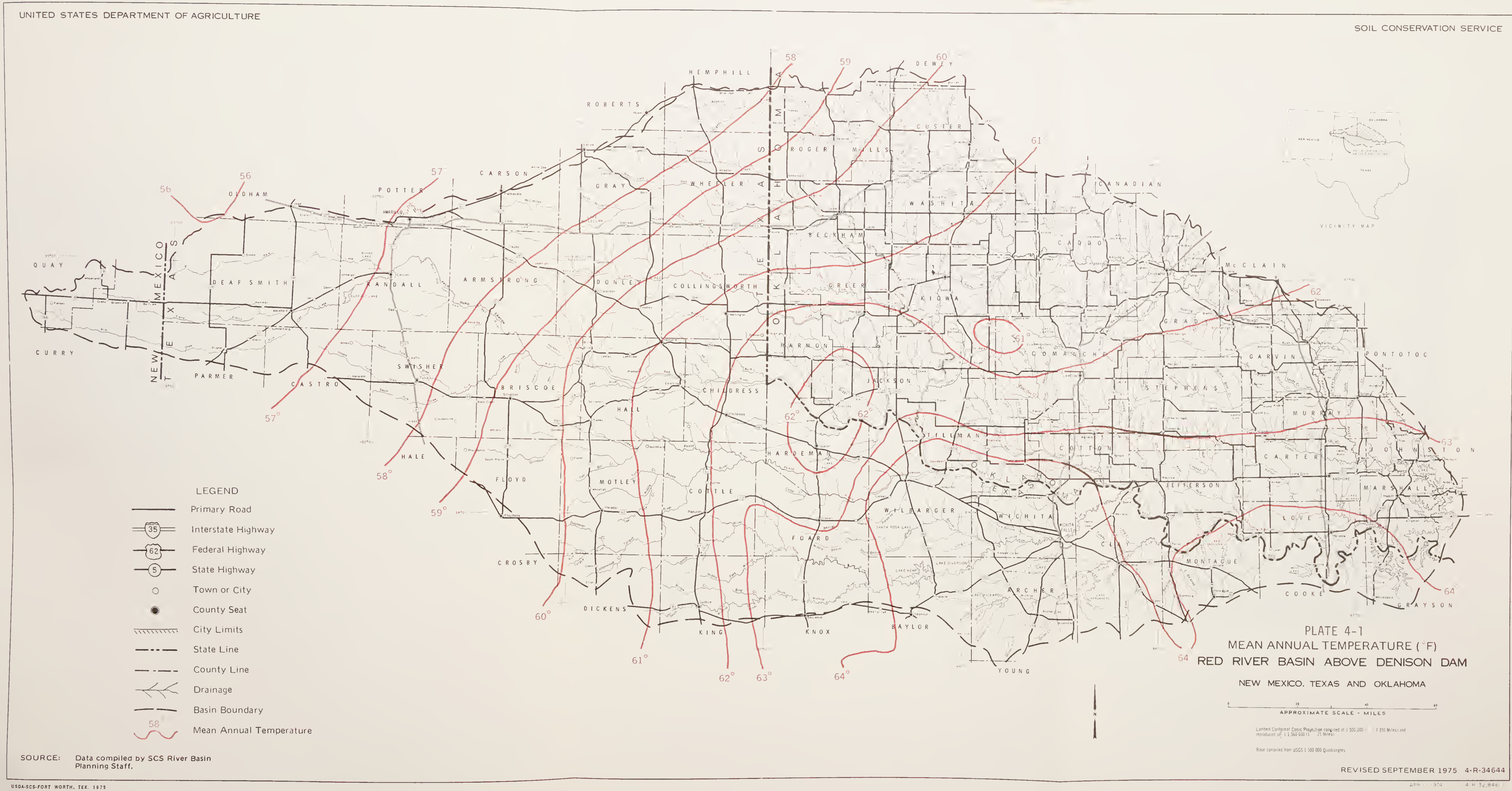
Triassic rocks belonging to the Dockum Group crop out in a narrow band along the High Plains escarpment of Texas. The Dockum is characterized by beds of conglomerate which form scarps and ledges.

The Permian Period consists of many varied evaporite formations and occupies large areas. These formations are commonly called "Red Beds". These units consist of alternating beds of red friable sandstone, shale, and some gypsum.

The Pennsylvanian Period consists of many formations that crop out in the eastern portion of the basin. The rocks are mostly marine deposits and consist of shale, sandstone, and limestone.

The Mississippian Age consists of rocks that crop out in the Arbuckle Mountain region (in Oklahoma). The formations are made up of shale, conglomerate, sandstone, and limestone.

The Ordovician Period consists of limestone rocks from the Arbuckle Group. These rocks are found in the Arbuckle and Wichita Mountain regions (in Oklahoma).


UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
PLATE 4-1
MEAN ANNUAL TEMPERATURE (°F)
RED RIVER BASIN ABOVE DENISON DAM
NEW MEXICO, TEXAS AND OKLAHOMA
APPROXIMATE SCALE - MILES
LEGEND
Primary Road
Interstate Highway
Federal Highway
State Highway
Town or City
County Seat
City Limits
State Line
County Line
Drainage
Basin Boundary
Mean Annual Temperature
SOURCE: Data compiled by SCS River Basin Planning Staff.
VICINITY MAP
REVISED SEPTEMBER 1975 4-R-34644
USDA-SCS-FORT WORTH, TEX. 1975
NEW MEXICO
TEXAS
OKLAHOMA
QUAY
CURRY
OLDHAM
DEAF SMITH
PARMER
POTTER
RANDALL
CASTRO
SWISHER
CARSON
ARMSTRONG
BRISCOE
HALE
FLOYD
CROSBY
DICKENS
MOTLEY
HALL
DONLEY
GRAY
ROBERTS
HEMPHILL
WHEELER
COLLINGSWORTH
CHILDRESS
COTTLE
KING
KNOX
FOARD
HARDEMAN
WILBARGER
BAYLOR
ARCHER
YOUNG
WICHITA
CLAY
MONTAGUE
COOKE
GRAYSON
LOVE
MARSHALL
JOHNSTON
CARTER
JEFFERSON
MURRAY
PONTOTOC
GARVIN
McCLAIN
GRADY
STEPHENS
COTTON
COMANCHE
TILLMAN
JACKSON
HARMON
GREER
KIOWA
CADDO
CANADIAN
WASHITA
BECKHAM
ROGER MILLS
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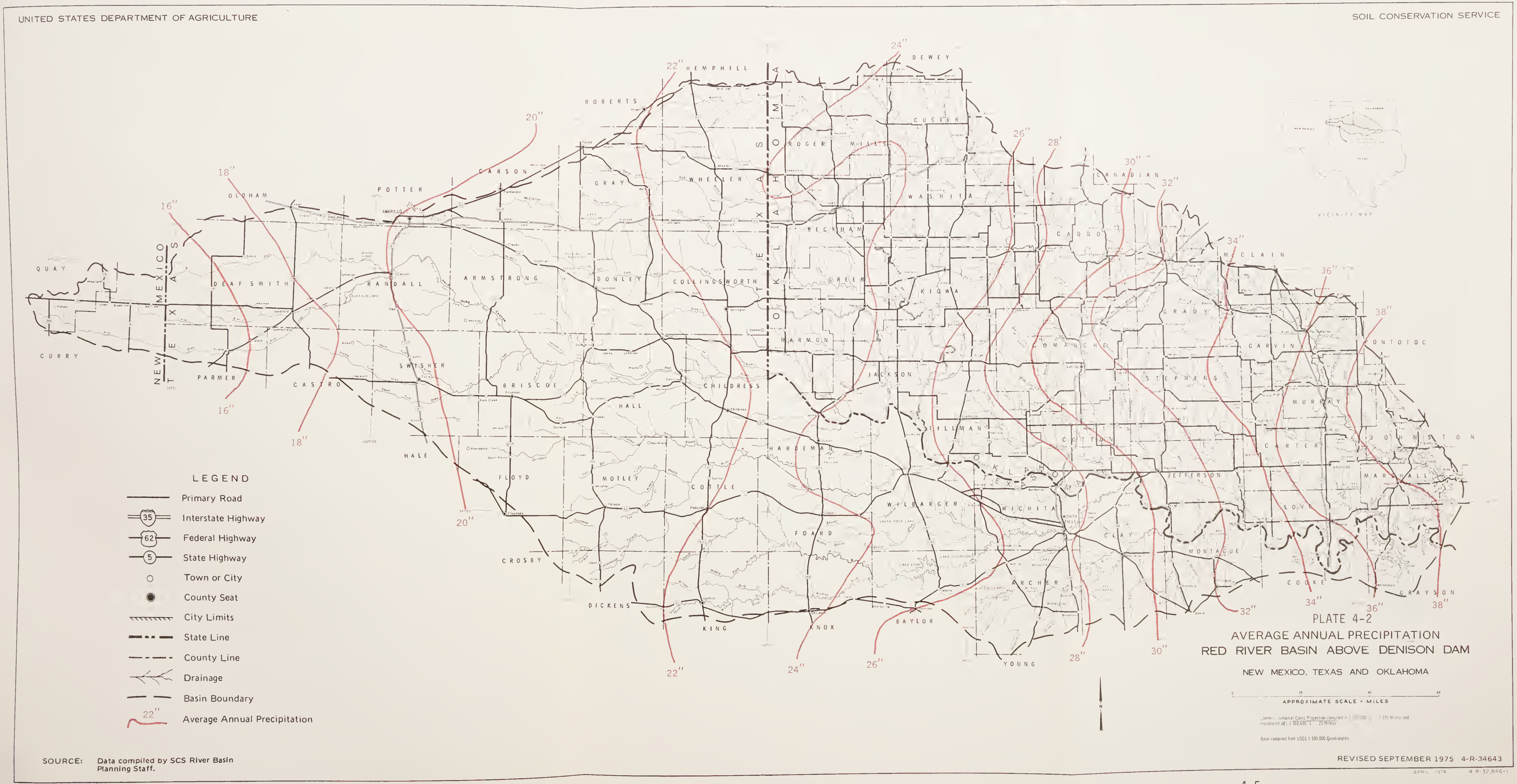

USDA-SCS-FORT WORTH TEXAS 1976

LEGEND

	TEXAS	TEXAS AND OKLAHOMA	OKLAHOMA	NEW MEXICO
QUATERNARY	Qs WINDBLOWN SAND Qcs WINDBLOWN COVER SAND Qtu / Se TULE FORM SEYMOUR FORM	Qas ALLUVIUM Qts TERRACE DEPOSITS		
TERTIARY		Tot OGALLALA 1/ FORMATION		Tom OGALLALA FORMATION
TRIASSIC 2/	Trd DOCKUM GROUP			
UPPER CRETACEOUS	Kef EAGLE FORD FORMATION	Kwb WOODBINE FORMATION		
LOWER CRETACEOUS		Kw WASHITA GROUP Kf FREDRICKSBURG GROUP Ka ANTLERS SAND	Kk KIOWA SHALE	
UPPER PERMIAN	Pqcw Pcwh	Pq QUARTERMASTER FORMATION CLOUDCHIEF FORMATION WHITEHORSE GROUP	Pcc Pwh Prs RUSH SPRINGS Pm MARLOW	
LOWER PERMIAN	Ps SAN ANGELO SANDSTONE Pcf CLEAR FORK GROUP Pw WICHITA GROUP	Pdc DOG CREEK SHALE Pb BLAINE FORMATION Pf FLOWERPOT SHALE	Pd-c DUNCAN-CHICKASHA FORMATION Phy HENNESSEY SHALE Pch CEDAR HILLS SANDSTONE MEMBER Pga GARBER SANDSTONE Pfa FALLIS SANDSTONE MEMBER Pa ADDINGTON FORMATION	
UPPER PENNSYLVANIAN	IPcs CISCO GROUP		IPcl CLAYPOOL FORMATION IPo OSCAR SANDSTONE IPv VANOSS FORMATION IPad ADA FORMATION	
LOWER PENNSYLVANIAN			IPh HOXBAR GROUP IPd DEESE GROUP IPdh DORNICK HILL GROUP	
UPPER MISSISSIPPIAN			Ms-Mg SPRINGER-GODDARD GROUP	
MIDDLE TO LOWER MISSISSIPPIAN			S-M SILURIAN-MIDDLE MISS. M-Uo MIDDLE MISS. - UPPER ORDOVICIAN	
LOWER ORDOVICIAN			L-O ARBUCKLE GROUP	
UPPER CAMBRIAN			Є-C COLBERT RHYOLITE PORPHYRY	
MIDDLE CAMBRIAN			M-Є GRANITE ROCKS	
LOWER CAMBRIAN			L-Є GRANITE ROCKS	
PRE-CAMBRIAN			PЄ-T TISHOMINGO GRANITE	

1/ In New Mexico the eolian and loess sediments of Quarternary age which mantle the Ogallala formation are not recognized as a separate formation as they are in Texas (QCS).

2/ The Triassic is out of place. It should have been placed between the Lower Cretaceous and Upper Permian.

NOTE: This map is preliminary in nature and is valid in Texas only, until publication of the Wichita Falls, Lawton, Clovis and Tucumcari sheets of the Geologic Atlas of Texas.

SOURCE: Preliminary compilation, Geologic Atlas of Texas, Bureau of Economic Geology, The University of Texas at Austin, Virgil E. Barnes, Project Director.

BACK 4-R-34682

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

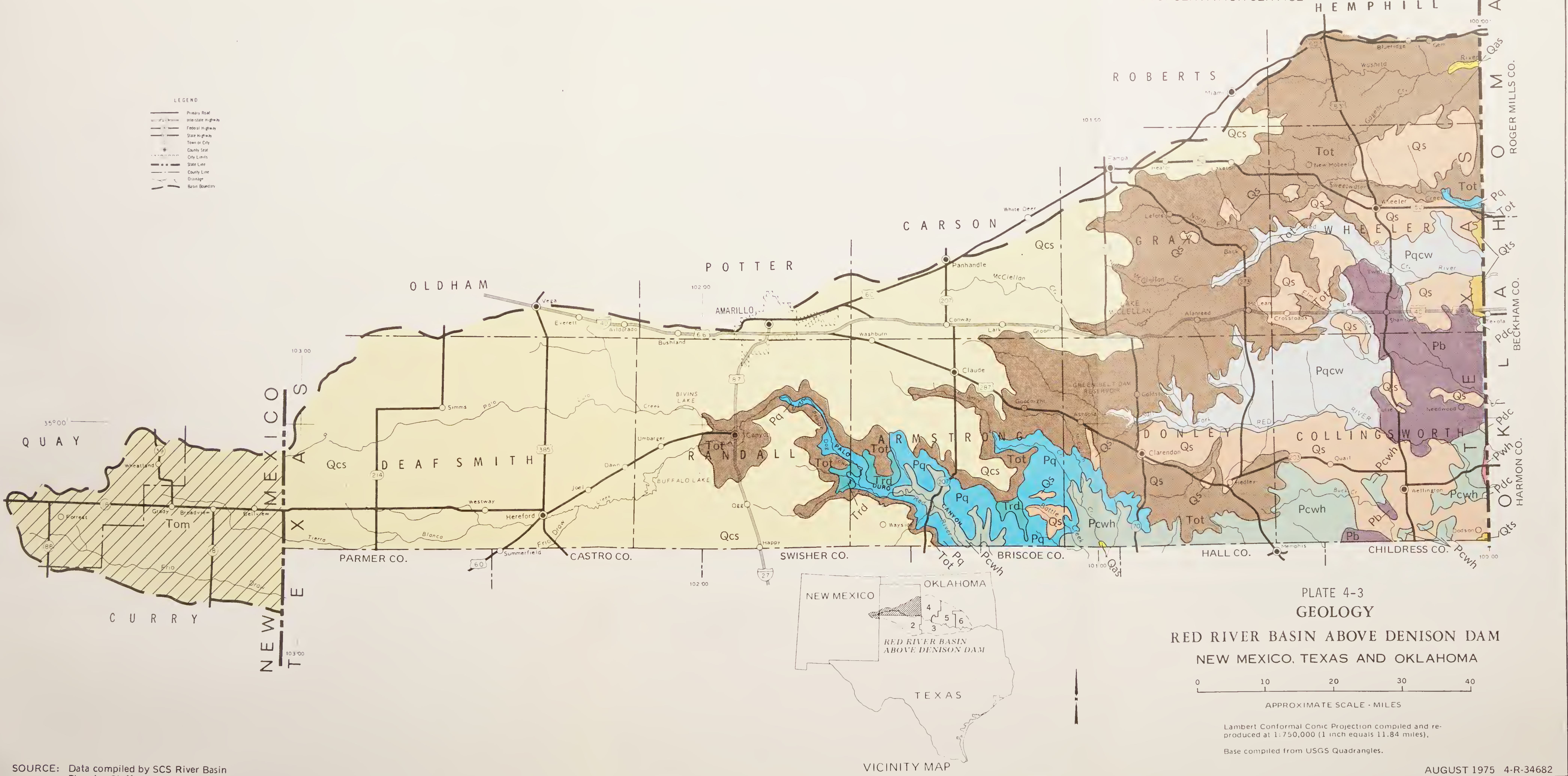

PLATE 4-3

GEOLOGY

RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA

Lambert Conformal Conic Projection compiled and reproduced at 1:750,000 (1 inch equals 11.84 miles).

Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

AUGUST 1975 4-R-34682

Sheet 1 of 6 JUNE 1975 BASE 4-R-32846-1-A

USDA-SCS-FORT WORTH, TEXAS 1976

LEGEND

	TEXAS	TEXAS AND OKLAHOMA	OKLAHOMA	NEW MEXICO
QUATERNARY	Qs WINDBLOWN SAND Qcs WINDBLOWN COVER SAND Qtu / Se TULE FORM SEYMOUR FORM	Qas ALLUVIUM Qts TERRACE DEPOSITS		
TERTIARY		Tot OGALLALA 1/ FORMATION		Tom OGALLALA FORMATION
TRIASSIC 2/	Trd DOCKUM GROUP			
UPPER CRETACEOUS	Kef EAGLE FORD FORMATION	Kwb WOODBINE FORMATION		
LOWER CRETACEOUS		Kw WASHITA GROUP Kf FREDRICKSBURG GROUP Ka ANTLERS SAND	Kk KIOWA SHALE	
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UPPER PENNSYLVANIAN	IPcs CISCO GROUP		IPcl CLAYPOOL FORMATION IPo OSCAR SANDSTONE IPv VANOSS FORMATION IPad ADA FORMATION	
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PRE-CAMBRIAN			PЄ-T TISHOMINGO GRANITE	

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BACK 4-R-34682

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

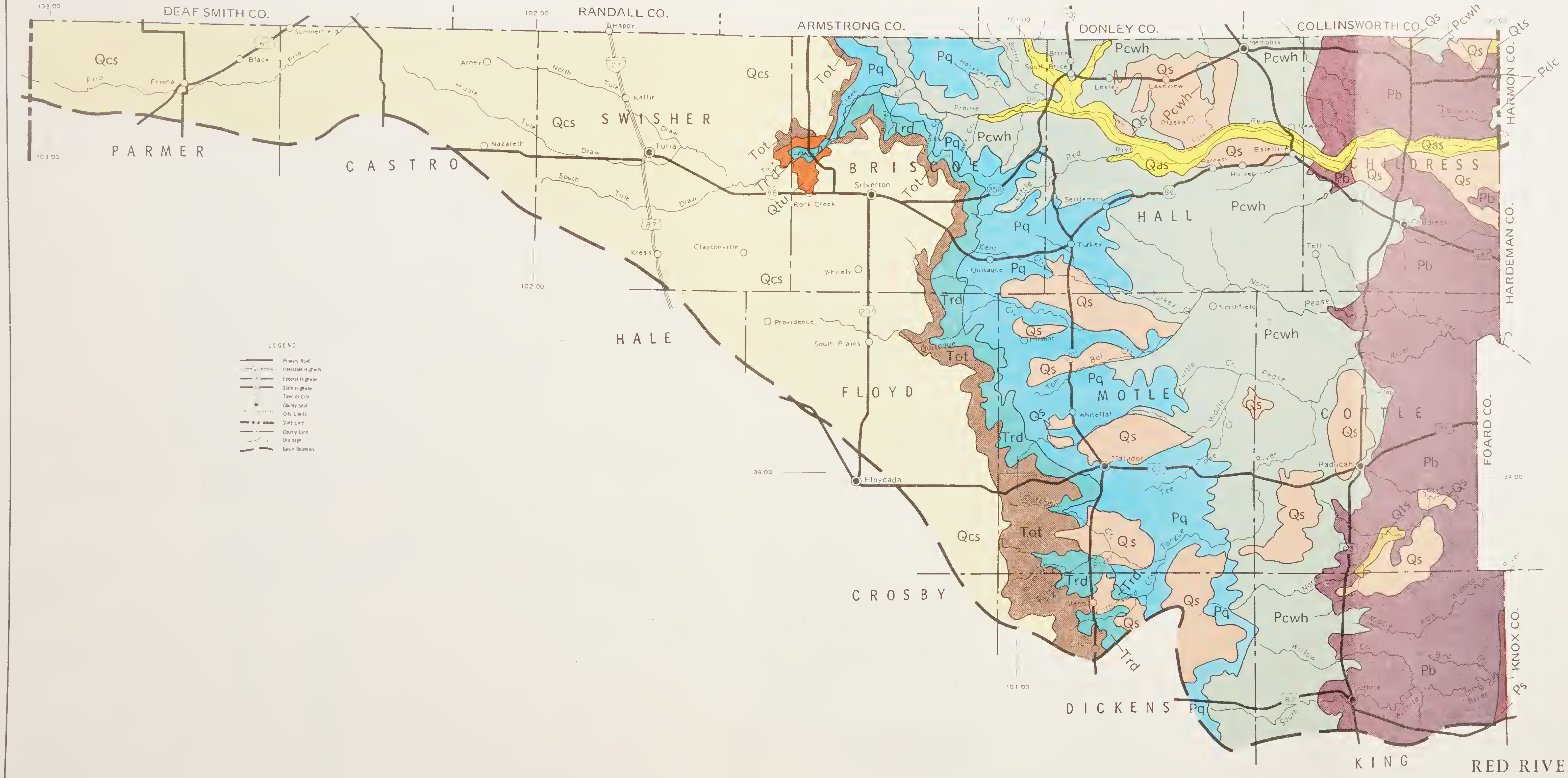

PLATE 4-3

GEOLOGY

RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA

0 10 20 30 40

APPROXIMATE SCALE - MILES

Lambert Conformal Conic Projection compiled and reproduced at 1:750,000 (1 inch equals 11.84 miles).

Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

AUGUST 1975 4-R-34682

USDA-SCS-FORT WORTH, TEXAS 1976

Sheet 2 of 6 JUNE 1975 BASE 4-R-32846-1-A

LEGEND

	TEXAS	TEXAS AND OKLAHOMA	OKLAHOMA	NEW MEXICO
QUATERNARY	Qs WINDBLOWN SAND Qcs WINDBLOWN COVER SAND Qtu / Se TULE FORM SEYMOUR FORM	Qas ALLUVIUM Qts TERRACE DEPOSITS		
TERTIARY		Tot OGALLALA 1/ FORMATION		Tom OGALLALA FORMATION
TRIASSIC 2/	Trd DOCKUM GROUP			
UPPER CRETACEOUS	Kef EAGLE FORD FORMATION	Kwb WOODBINE FORMATION		
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LOWER PERMIAN	Ps SAN ANGELO SANDSTONE Pcf CLEAR FORK GROUP Pw WICHITA GROUP	Pdc DOG CREEK SHALE Pb BLAINE FORMATION Pf FLOWERPOT SHALE	Pd-c DUNCAN-CHICKASHA FORMATION Phy HENNESSEY SHALE Pch CEDAR HILLS SANDSTONE MEMBER Pga GARBER SANDSTONE Pfa FALLIS SANDSTONE MEMBER Pa ADDINGTON FORMATION	
UPPER PENNSYLVANIAN	IPcs CISCO GROUP		IPcl CLAYPOOL FORMATION IPo OSCAR SANDSTONE IPv VANOSS FORMATION IPad ADA FORMATION	
LOWER PENNSYLVANIAN			IPh HOXBAR GROUP IPd DEESE GROUP IPdh DORNICK HILL GROUP	
UPPER MISSISSIPPIAN			Ms-Mg SPRINGER-GODDARD GROUP	
MIDDLE TO LOWER MISSISSIPPIAN			S-M SILURIAN-MIDDLE MISS. M-Uo MIDDLE MISS. - UPPER ORDOVICIAN	
LOWER ORDOVICIAN			L-O ARBUCKLE GROUP	
UPPER CAMBRIAN			Є-C COLBERT RHYOLITE PORPHYRY	
MIDDLE CAMBRIAN			M-Є GRANITE ROCKS	
LOWER CAMBRIAN			L-Є GRANITE ROCKS	
PRE-CAMBRIAN			PЄ-T TISHOMINGO GRANITE	

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SOURCE: Preliminary compilation, Geologic Atlas of Texas, Bureau of Economic Geology, The University of Texas at Austin, Virgil E. Barnes, Project Director.

BACK 4-R-34682

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

PLATE 4-3

GEOLOGY

RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA

0 10 20 30 40

APPROXIMATE SCALE - MILES

Lambert Conformal Conic Projection compiled and reproduced at 1:750,000 (1 inch equals 11.84 miles).

Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

AUGUST 1975 4-R-34682

LEGEND

	TEXAS	TEXAS AND OKLAHOMA	OKLAHOMA	NEW MEXICO
QUATERNARY	Qs WINDBLOWN SAND Qcs WINDBLOWN COVER SAND Qtu / Se TULE FORM SEYMOUR FORM	Qas ALLUVIUM Qts TERRACE DEPOSITS		
TERTIARY		Tot OGALLALA FORMATION 1/		Tom OGALLALA FORMATION
TRIASSIC 2/	Trd DOCKUM GROUP			
UPPER CRETACEOUS	Kef EAGLE FORD FORMATION	Kwb WOODBINE FORMATION		
LOWER CRETACEOUS		Kw WASHITA GROUP Kf FREDRICKSBURG GROUP Ka ANTLERS SAND	Kk KIOWA SHALE	
UPPER PERMIAN	Pqcw Pcwh	Pq QUARTERMASTER FORMATION CLOUDCHIEF FORMATION WHITEHORSE GROUP	Pcc Pwh Prs RUSH SPRINGS Pm MARLOW	
LOWER PERMIAN	Ps SAN ANGELO SANDSTONE Pcf CLEAR FORK GROUP Pw WICHITA GROUP	Pdc DOG CREEK SHALE Pb BLAINE FORMATION Pf FLOWERPOT SHALE	Pd-c DUNCAN-CHICKASHA FORMATION Phy HENNESSEY SHALE Pch CEDAR HILLS SANDSTONE MEMBER Pga GARBER SANDSTONE Pfa FALLIS SANDSTONE MEMBER Pa ADDINGTON FORMATION	
UPPER PENNSYLVANIAN	IPcs CISCO GROUP		IPcl CLAYPOOL FORMATION IPo OSCAR SANDSTONE IPv VANOSS FORMATION IPad ADA FORMATION	
LOWER PENNSYLVANIAN			IPh HOXBAR GROUP IPd DEESE GROUP IPdh DORNICK HILL GROUP	
UPPER MISSISSIPPIAN			Ms-Mg SPRINGER-GODDARD GROUP	
MIDDLE TO LOWER MISSISSIPPIAN			S-M SILURIAN-MIDDLE MISS. M-Uo MIDDLE MISS. - UPPER ORDOVICIAN	
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UPPER CAMBRIAN			Є-C COLBERT RHYOLITE PORPHYRY	
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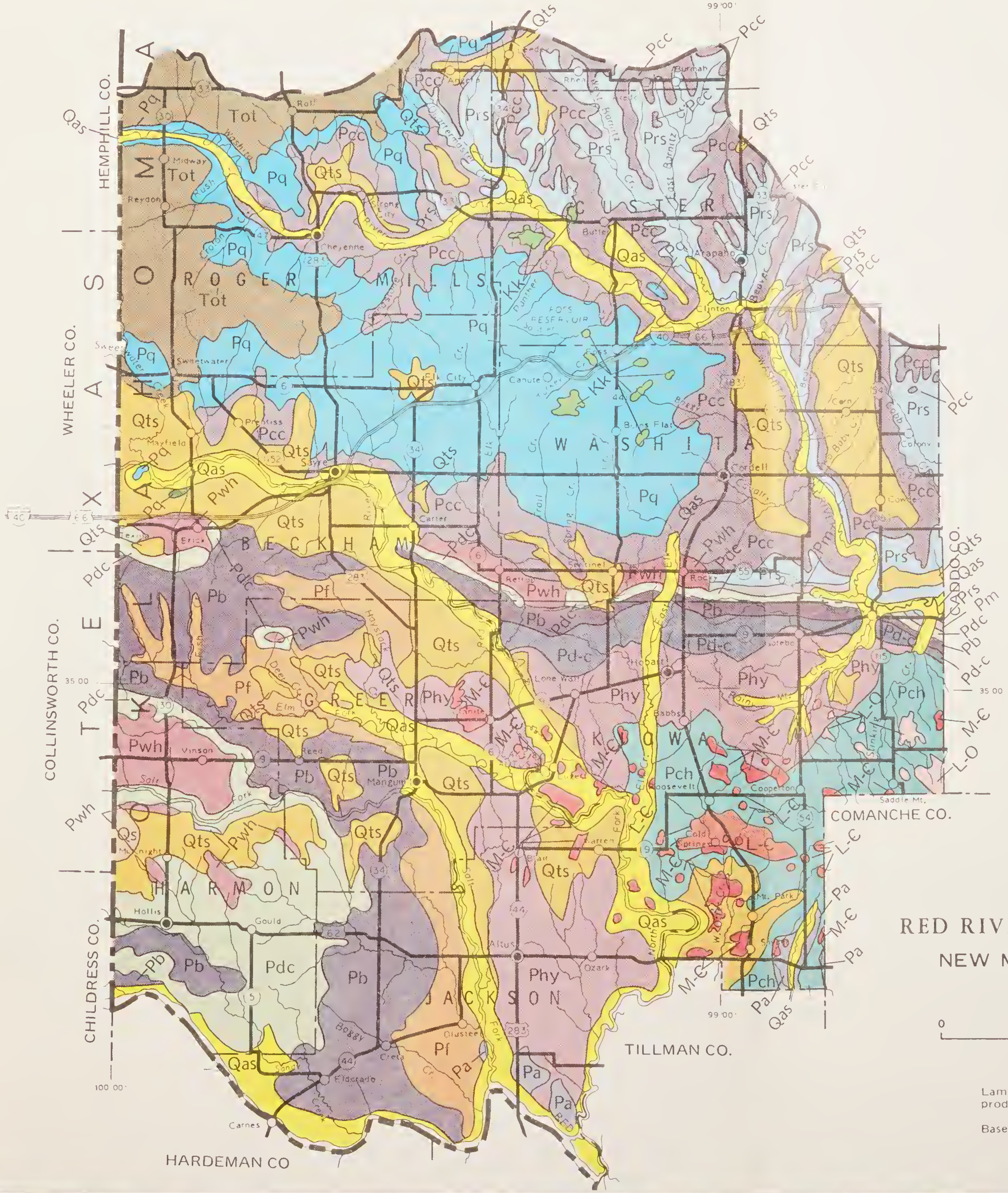
BACK 4-R-34682

LEGEND

- Primary Road
- Interstate Highway
- Federal Highway
- State Highway
- Town or City
- County Seat
- City Limits
- State Line
- County Line
- Drainage
- Basin Boundary



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SOURCE: Data compiled by SCS River Basin Planning Staff.

AUGUST 1975 4-R-34682

USDA-SCS-FORT WORTH, TEXAS 1976

Sheet 4 of 6 JUNE 1975 BASE 4-R-32846-1-A

LEGEND

	TEXAS	TEXAS AND OKLAHOMA	OKLAHOMA	NEW MEXICO
QUATERNARY	Qs WINDBLOWN SAND Qcs WINDBLOWN COVER SAND Qtu / Se TULE FORM SEYMOUR FORM	Qas ALLUVIUM Qts TERRACE DEPOSITS		
TERTIARY		Tot OGALLALA 1/ FORMATION		Tom OGALLALA FORMATION
TRIASSIC 2/	Trd DOCKUM GROUP			
UPPER CRETACEOUS	Kef EAGLE FORD FORMATION	Kwb WOODBINE FORMATION		
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BACK 4-R-34682

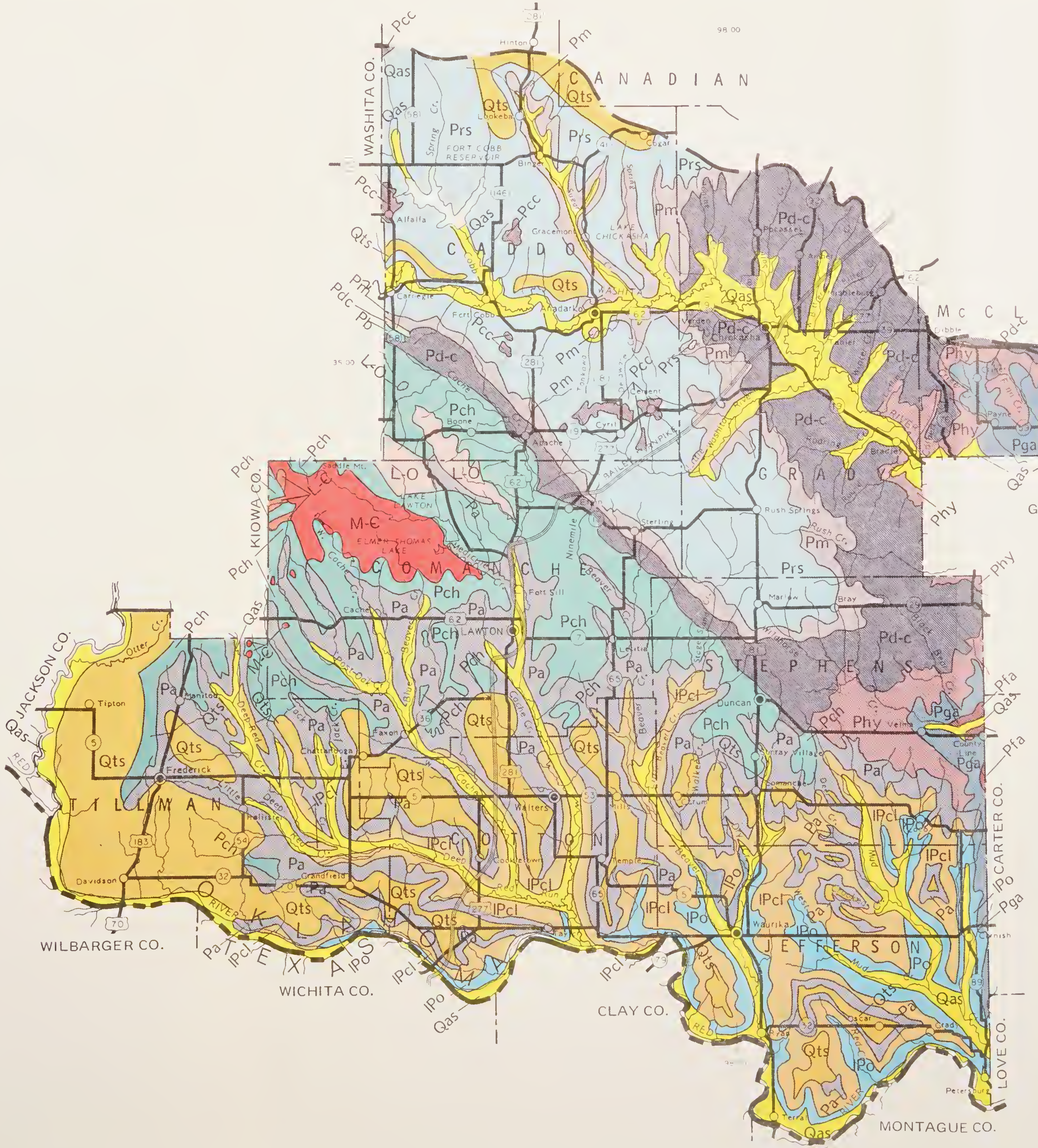

PLATE 4-3

GEOLOGY

RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA

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APPROXIMATE SCALE - MILES

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Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

AUGUST 1975 4-R-34682

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MIDDLE CAMBRIAN			M-€ GRANITE ROCKS	
LOWER CAMBRIAN			L-€ GRANITE ROCKS	
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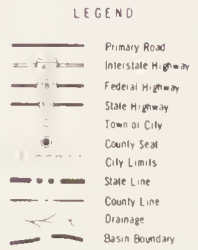
BACK 4-R-34682



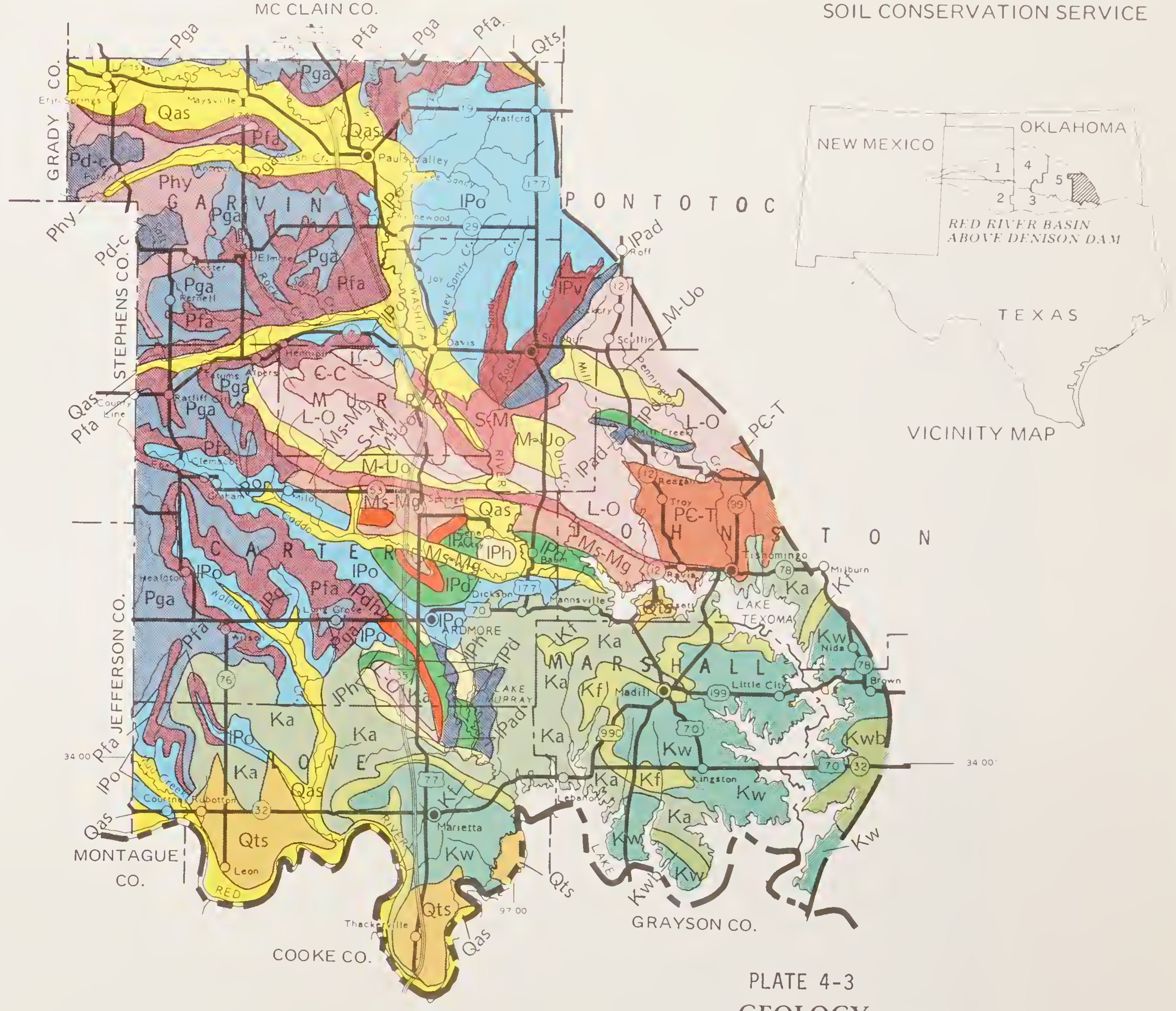


PLATE 4-3

GEOLOGY

RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA

0 10 20 30 40

APPROXIMATE SCALE - MILES

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Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

AUGUST 1975 4-R-34682

USDA-SCS-FORT WORTH, TEXAS 1976

The Cambrian rocks consist of rhyolite and granite and are found locally in the Arbuckle and Wichita Moutain areas.

The Pre-Cambrian rocks consist of the Tishomingo Granite that crops out in the Arbuckle Mountains. These rocks are among the oldest in the world.

Detailed information on the geology in the Texas portion of the basin may be found in a special report entitled; "Geology, Erosion, and Sedimentation in the Red River Basin Above Denison Dam (Texas)".

TOPOGRAPHY

The topography within the basin is illustrated on Plate 4-4. Elevations range from above 4,800 feet above mean sea level in the extreme western portion of the basin to about 600 feet in the eastern portion. Slopes range from one tenth percent on the high plains to over one hundred percent in the escarpment areas. Some portions of the basin in Oklahoma are considered mountainous.

SOILS

The soils within the basin range from deep, nearly level loamy upland soils of the high plains to the very shallow, steeply sloping upland soils of rock outcrop and rough, broken land.

Many of the soils have low fertility and are susceptible to erosion both by water and wind. Some of them are affected by detrimental salinity levels. Many of the soils are underlain by geologic formations containing gypsum and gravel which, are therefore, present in the overlying soils.

The soils have been mapped in detail over much of the study area. Published, modern soil survey reports are available for over half of the counties within the study area.

A general soil map of the basin is shown as Plate 4-5. The line and symbol delineations on this map show important soil associations. The area within the delineations of a soil association is occupied by two or more series of major extent and several series of lesser extent.

The association name is derived from the series of major extent and usually occupies from 65 to 96 percent of its area. The remainder of the area is occupied by the soil series of lesser extent. There are 51 soil associations in the Red River Basin Above Denison Dam study area. These associations

have been placed into 16 groups based on generalized similarities. Table 4-1 shows the acreage in these groups, which are the colored units on the map.

TABLE 4-1

Acreage by Soil Groups

Red River Basin Above Denison Dam

Soil Group	Acres by State			Total Acres	Percent
	Texas	Oklahoma	New Mexico		
I	3,349,200	-	380,000	3,729,200	14.7
II	2,449,800	2,096,600	-	4,546,400	17.9
III	1,757,300	1,087,300	-	2,844,600	11.2
IV	1,305,400	406,100	-	1,711,500	6.7
V	1,260,700	2,973,400	-	4,234,100	16.7
VI	1,129,500	-	-	1,129,500	4.4
VII	860,700	1,138,900	-	1,999,600	7.9
VIII	560,500	-	44,600	605,100	2.4
IX	412,600	1,200,100	-	1,612,700	6.3
X	405,700	-	-	405,700	1.6
XI	311,200	393,200	-	704,400	2.8
XII	231,100	879,900	-	1,111,000	4.4
XIII	80,300	-	-	80,300	0.3
XIV	73,200	176,200	-	249,400	1.0
XV	38,200	328,800	-	367,000	1.4
XVI	-	63,390	-	63,390	0.3
Total	14,225,400	10,743,890	424,600	25,393,890	100.0

Source: Special Report - Soils - Red River Basin Above Denison Dam, USDA, February 1977

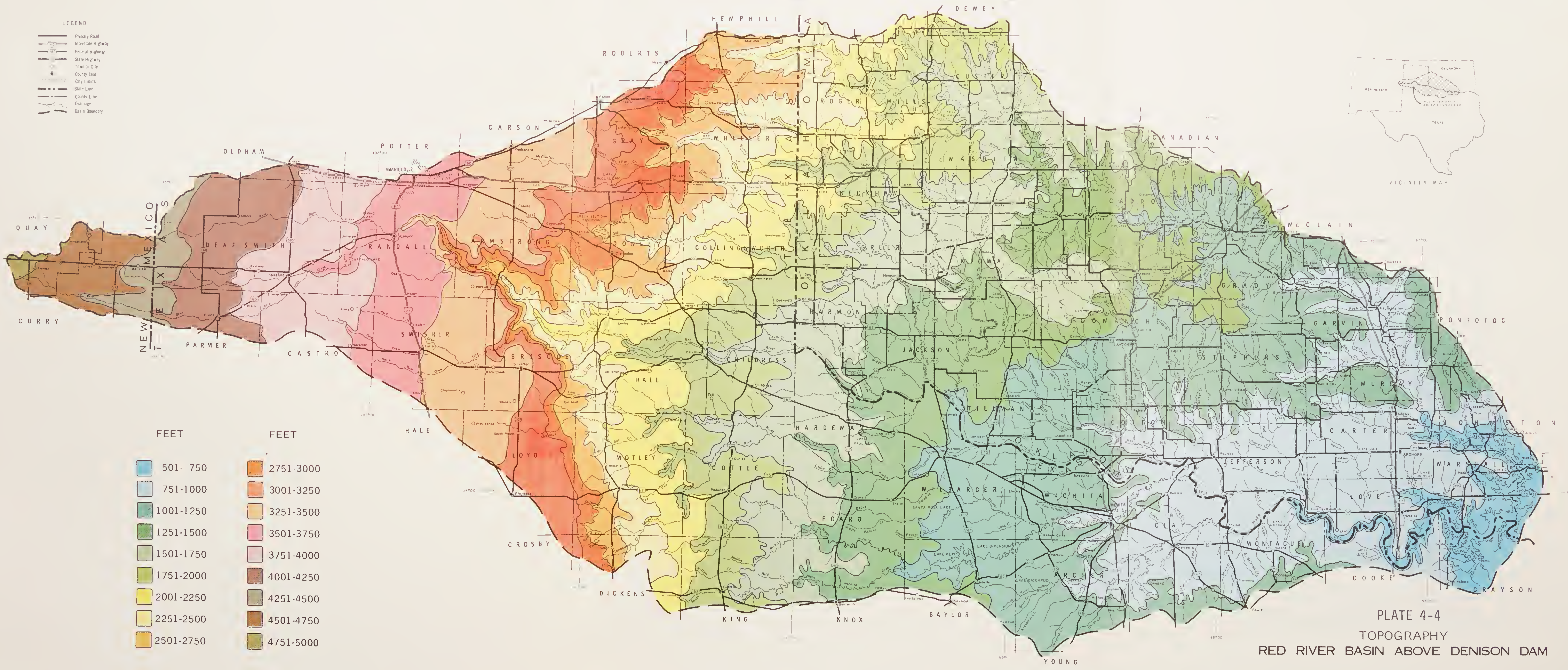


PLATE 4-4

TOPOGRAPHY

RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA

APPROXIMATE SCALE – MILES

Base compiled from USGS Quad Sheets, Lambert Conformal Conic Projection

SOURCE: Data compiled by SCS River Basin Planning Staff.

FEBRUARY 1975 4-R-34667

APRIL 1974 4-R-32846-1

LEGEND

Soil associations are listed below by major soil groups. Each soil group is briefly described and consists of one or more related soil association. The associations are the units delineated on the map. They have hyphenated names made up of two or three soil series of major extent within the delineations. Other series of minor extent are included in each delineation. Association symbols on the map consist of consecutive numbers 1 thru 51.

I Deep, nearly level to gently sloping loamy upland soils with loamy to clayey subsoils and level, poorly drained, clayey soils in playas. Permeability is moderate to very slow.

1 Olton-Pullman-Acuff
2 Pullman-Randall

II Deep to moderately deep, nearly level to gently sloping loamy soils with clayey subsoils; some shallow soils clayey throughout; some subsoils high in sodium; all upland soils having moderately slow to very slow permeabilities.

3 Abilene-Hollister
4 Kamay-Bluegrove-Deandale
5 Renfrow-Bluegrove-Stoneburg
6 Renfrow-Kirkland
7 Tillman-Hollister-Foard
8 Tillman-Vernon-Owens
9 Zaneis-Foard-Wing

III Deep, nearly level to undulating soils with sandy surface layers and loamy to sandy subsoils and some soils sandy throughout with duny topography. Permeability is moderate to rapid.

10 Devol-Likes-Tivoli
11 Heaily-Nobscot-Delwin
12 Konawa-Dougherty-Eufaula
13 Miles-Springer

IV Deep to moderately deep, nearly level to sloping loamy or clayey upland soils with moderately rapid to moderately slow permeability.

14 Miles-Bukreek-Sagerton
15 Miles-Sagerton-Aspermont
16 Miles-Tipton-Hardeman
17 Minco-Teller-Pond Creek
18 Motley-Frankirk
19 Sagerton-Bukreek-Aspermont
20 Tipton-Hardeman-Grandfield

V Shallow to deep, nearly level to rolling, loamy upland soils. Permeability is moderately slow to moderately rapid.

21 Carey-Woodward-Obaro
22 Dill-Quinlan
23 Pond Creek-Cobb
24 Woodward-Quinlan-Obaro
25 Woodward-Quinlan-St. Paul
26 Zaneis-Lucien-Grant

VI Deep to moderately deep loamy soils and shallow to very shallow loamy soils underlain with sandstone or caliche on gently sloping to very steep uplands. Permeability is moderate to moderately rapid.

27 Berda-Mobeetie-Potter
28 Burson-Quinlan-Obaro

VII Very shallow to deep, gently sloping to steep loamy and clayey upland soils overlying clayey shale, sandstone, gypsum and limestone. Some areas of rock outcrop or rough broken land are intermingled with these soils. Permeability is moderate to very slow.

29 Cordell-Obaro
30 Kiti-Lula-Rock Outcrop
31 Lawton-Talpa-Rock Outcrop
32 Owens-Cottonwood-Talpa
33 Owens-Knoco-Vernon

VIII Deep or moderately deep, nearly level to strongly sloping loamy, moderately permeable upland soils.

34 Estacado-Mansker
35 Mansker-Bippus-Berda

IX Deep, moderately deep and shallow, nearly level to steep upland soils with loamy to sandy surface layers. Permeability is moderately slow to moderately rapid.

36 Bonti-Cona
37 Callisburg-Truce-Gasil
38 Stephenville-Darnell-Windthorst
39 Windthorst-Duffau-Truce

X Deep to moderately deep, nearly level to gently sloping loamy soils; very shallow, gently sloping to steep, loamy stony soils underlain with limestone and some deep, clayey stony soils. Permeability is moderate to very slow in these upland soils.

40 Maloterre-Venus-Heiden
41 Quanah-Talpa

XI Deep, nearly level to strongly sloping loamy upland soils of stream terraces; nearly level loamy to sandy bottom land soils, and deep sandy upland soils with duny topography. Permeability is moderate to rapid.

42 Enterprise-Lincoln-Tipton
43 Lincoln-Yahola-Crevasse
44 Teller-Minco-Yahola
45 Tivoli-Enterprise-Lincoln

XII Nearly level, moderately and moderately rapidly permeable loamy bottom land soils and clayey very slowly permeable bottom land soils.

46 Clairemont-Mangum-Yomont
47 Clairemont-Port-Miller

XIII Deep gravelly soils and very shallow loamy soils underlain with sandstone on undulating to hilly uplands. Permeability is moderate to moderately rapid.

48 Polar-Latom

XIV Deep or moderately deep, nearly level to gently sloping, clayey upland soils. Permeability is very slow.

49 Heiden-Ellis-Houston Black

XV Deep, nearly level to gently sloping upland soils with loamy surfaces and clayey subsoils. Permeability is very slow.

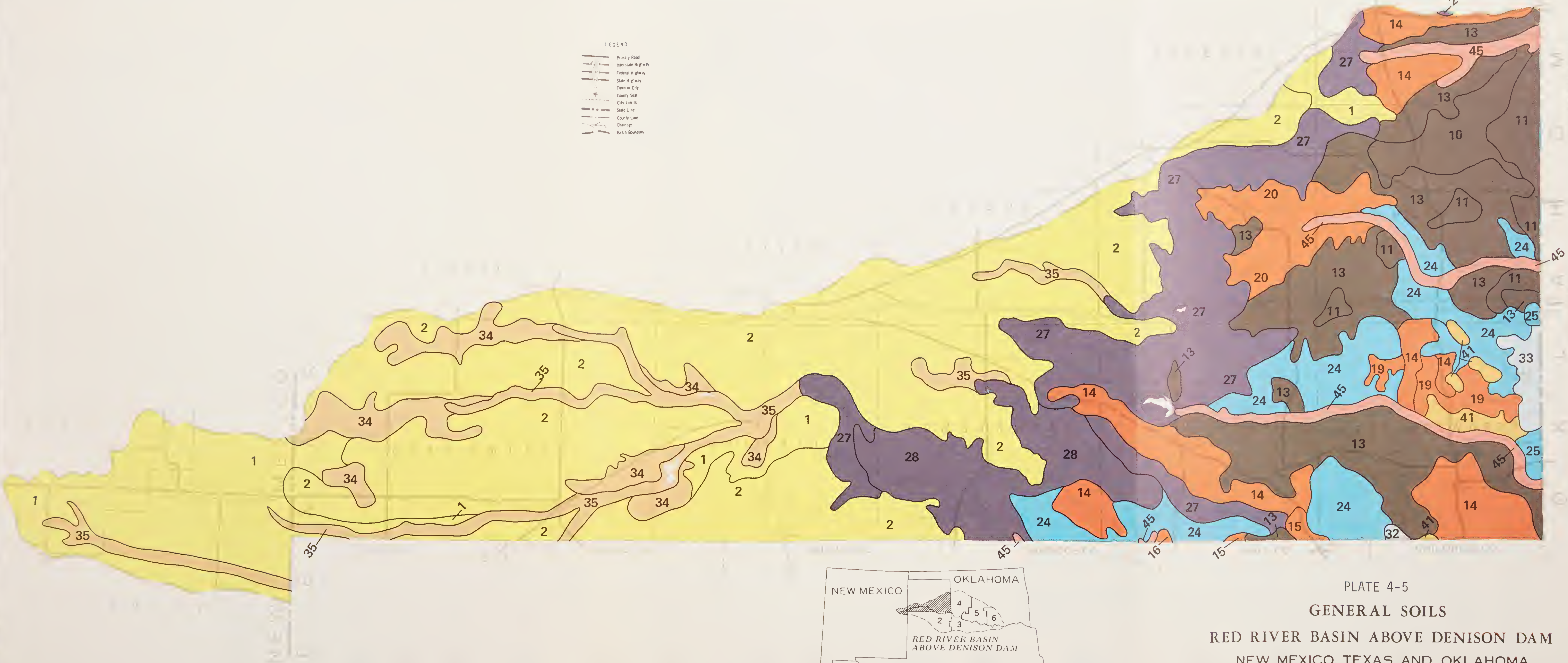
50 Normangee-Wilson-Crockett

XVI Deep, nearly level to sloping loamy upland soils with clayey subsoils; some soils are loamy throughout. Permeability is very slow to moderately slow.

51 Chigley-Agan-Ravia

BACK 4-R-34945

NOTE: This General Soil Map is suitable for broad planning purposes only. For more detailed planning on individual tracts of land, a detailed soil survey is needed.



VICINITY MAP

PLATE 4-5

GENERAL SOILS

RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA

0 10 20 30 40

APPROXIMATE SCALE - MILES

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Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

USDA-SCS-FORT WORTH, TEX. 1976

OCTOBER 1975 4-R-34945

Sheet 1 of 6 JUNE 1975 BASE 4-R-32846-1-A

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II — Deep to moderately deep, nearly level to gently sloping loamy soils with clayey subsoils; some shallow soils clayey throughout; some subsoils high in sodium; all upland soils having moderately slow to very slow permeabilities.

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BACK 4-R-34945

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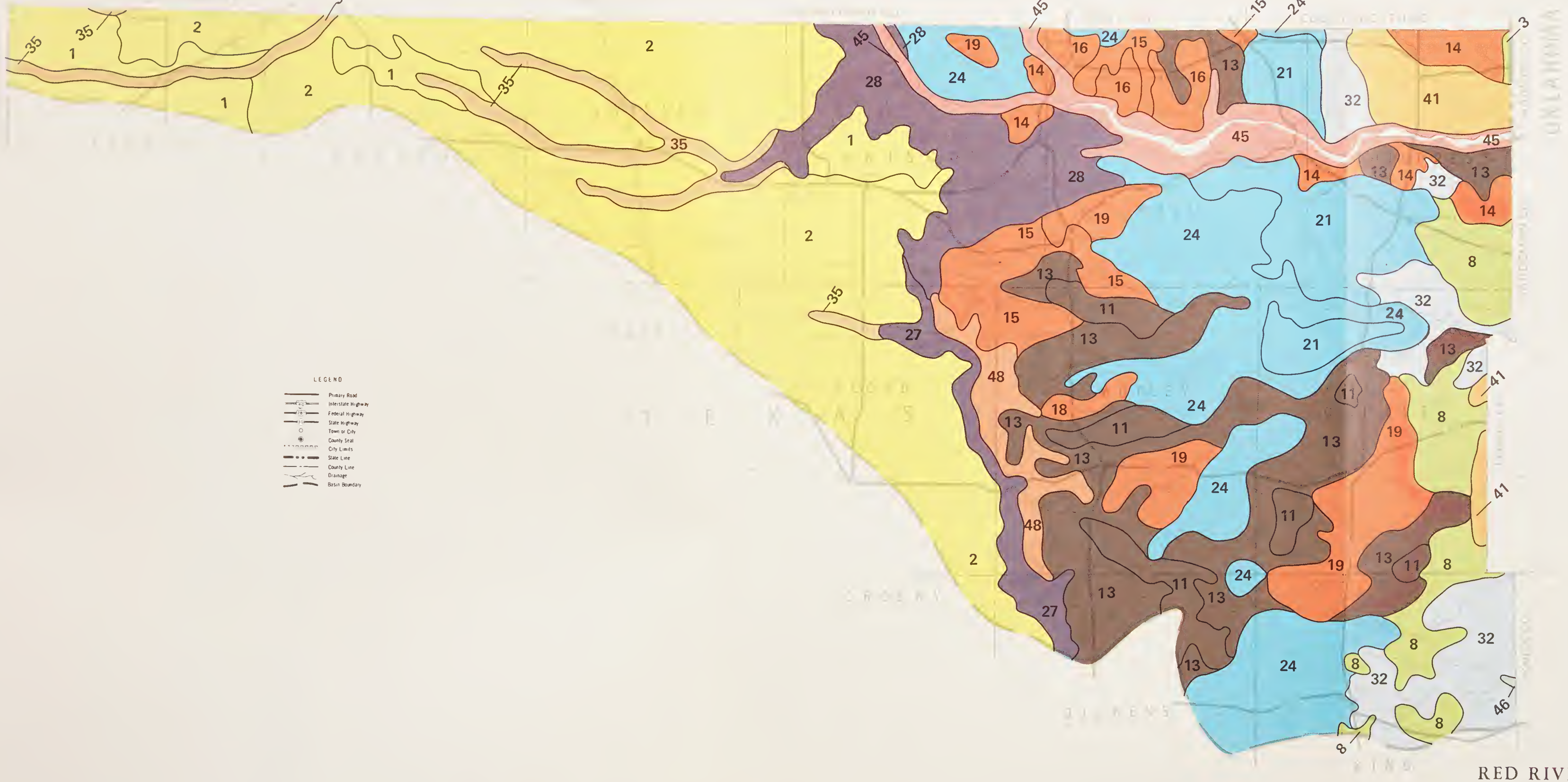
U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE



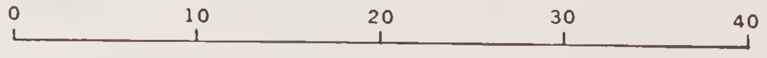
VICINITY MAP

PLATE 4-5

GENERAL SOILS

RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA



APPROXIMATE SCALE - MILES

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Base compiled from USGS Quadrangles.

SOURCE: Data compiled by SCS River Basin Planning Staff.

USDA-SCS-FORT WORTH, TEX. 1976

OCTOBER 1975 4-R-34945

Sheet 2 of 6 JUNE 1975 BASE 4-R-32846-1-A

LEGEND

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I Deep, nearly level to gently sloping loamy upland soils with loamy to clayey subsoils and level, poorly drained, clayey soils in playas. Permeability is moderate to very slow.

1 Olton-Pullman-Acuff
2 Pullman-Randall

II Deep to moderately deep, nearly level to gently sloping loamy soils with clayey subsoils; some shallow soils clayey throughout; some subsoils high in sodium; all upland soils having moderately slow to very slow permeabilities.

3 Abilene-Hollister
4 Kamay-Bluegrove-Deandale
5 Renfrow-Bluegrove-Stoneburg
6 Renfrow-Kirkland
7 Tillman-Hollister-Foard
8 Tillman-Vernon-Owens
9 Zaneis-Foard-Wing

III Deep, nearly level to undulating soils with sandy surface layers and loamy to sandy subsoils and some soils sandy throughout with duny topography. Permeability is moderate to rapid.

10 Devol-Likes-Tivoli
11 Heaily-Nobscot-Delwin
12 Konawa-Dougherty-Eufaula
13 Miles-Springer

IV Deep to moderately deep, nearly level to sloping loamy or clayey upland soils with moderately rapid to moderately slow permeability.

14 Miles-Bukreek-Sagerton
15 Miles-Sagerton-Aspermont
16 Miles-Tipton-Hardeman
17 Minco-Teller-Pond Creek
18 Motley-Frankirk
19 Sagerton-Bukreek-Aspermont
20 Tipton-Hardeman-Grandfield

V Shallow to deep, nearly level to rolling, loamy upland soils. Permeability is moderately slow to moderately rapid.

21 Carey-Woodward-Obaro
22 Dill-Quinlan
23 Pond Creek-Cobb
24 Woodward-Quinlan-Obaro
25 Woodward-Quinlan-St. Paul
26 Zaneis-Lucien-Grant

VI Deep to moderately deep loamy soils and shallow to very shallow loamy soils underlain with sandstone or caliche on gently sloping to very steep uplands. Permeability is moderate to moderately rapid.

27 Berda-Mobeetie-Potter
28 Burson-Quinlan-Obaro

VII Very shallow to deep, gently sloping to steep loamy and clayey upland soils overlying clayey shale, sandstone, gypsum and limestone. Some areas of rock outcrop or rough broken land are intermingled with these soils. Permeability is moderate to very slow.

29 Cordell-Obaro
30 Kiti-Lula-Rock Outcrop
31 Lawton-Talpa-Rock Outcrop
32 Owens-Cottonwood-Talpa
33 Owens-Knoco-Vernon

VIII Deep or moderately deep, nearly level to strongly sloping loamy, moderately permeable upland soils.

34 Estacado-Mansker
35 Mansker-Bippus-Berda

IX Deep, moderately deep and shallow, nearly level to steep upland soils with loamy to sandy surface layers. Permeability is moderately slow to moderately rapid.

36 Bonti-Cona
37 Callisburg-Truce-Gasil
38 Stephenville-Darnell-Windthorst
39 Windthorst-Duffau-Truce

X Deep to moderately deep, nearly level to gently sloping loamy soils; very shallow, gently sloping to steep, loamy stony soils underlain with limestone and some deep, clayey stony soils. Permeability is moderate to very slow in these upland soils.

40 Maloterre-Venus-Heiden
41 Quanah-Talpa

XI Deep, nearly level to strongly sloping loamy upland soils of stream terraces; nearly level loamy to sandy bottom land soils, and deep sandy upland soils with duny topography. Permeability is moderate to rapid.

42 Enterprise-Lincoln-Tipton
43 Lincoln-Yahola-Crevasse
44 Teller-Minco-Yahola
45 Tivoli-Enterprise-Lincoln

XII Nearly level, moderately and moderately rapidly permeable loamy bottom land soils and clayey very slowly permeable bottom land soils.

46 Clairemont-Mangum-Yomont
47 Clairemont-Port-Miller

XIII Deep gravelly soils and very shallow loamy soils underlain with sandstone on undulating to hilly uplands. Permeability is moderate to moderately rapid.

48 Polar-Latom

XIV Deep or moderately deep, nearly level to gently sloping, clayey upland soils. Permeability is very slow.

49 Heiden-Ellis-Houston Black

XV Deep, nearly level to gently sloping upland soils with loamy surfaces and clayey subsoils. Permeability is very slow.

50 Normangee-Wilson-Crockett

XVI Deep, nearly level to sloping loamy upland soils with clayey subsoils; some soils are loamy throughout. Permeability is very slow to moderately slow.

51 Chigley-Agan-Ravia

BACK 4-R-34945

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PLATE 4-5

GENERAL SOILS

RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA

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USDA-SCS-FORT WORTH, TEX. 1976

Sheet 3 of 6 JUNE 1975 BASE 4-R-32846-1-A

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2 Pullman-Randall

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3 Abilene-Hollister
4 Kamay-Bluegrove-Deandale
5 Renfrow-Bluegrove-Stoneburg
6 Renfrow-Kirkland
7 Tillman-Hollister-Foard
8 Tillman-Vernon-Owens
9 Zaneis-Foard-Wing

III Deep, nearly level to undulating soils with sandy surface layers and loamy to sandy subsoils and some soils sandy throughout with duny topography. Permeability is moderate to rapid.

10 Devol-Likes-Tivoli
11 Heaily-Nobscot-Delwin
12 Konawa-Dougherty-Eufaula
13 Miles-Springer

IV Deep to moderately deep, nearly level to sloping loamy or clayey upland soils with moderately rapid to moderately slow permeability.

14 Miles-Bukreek-Sagerton
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17 Minco-Teller-Pond Creek
18 Motley-Frankirk
19 Sagerton-Bukreek-Aspermont
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21 Carey-Woodward-Obaro
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27 Berda-Mobeetie-Potter
28 Burson-Quinlan-Obaro

VII Very shallow to deep, gently sloping to steep loamy and clayey upland soils overlying clayey shale, sandstone, gypsum and limestone. Some areas of rock outcrop or rough broken land are intermingled with these soils. Permeability is moderate to very slow.

29 Cordell-Obaro
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34 Estacado-Mansker
35 Mansker-Bippus-Berda

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50 Normangee-Wilson-Crockett

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51 Chigley-Agan-Ravia

BACK 4-R-34945

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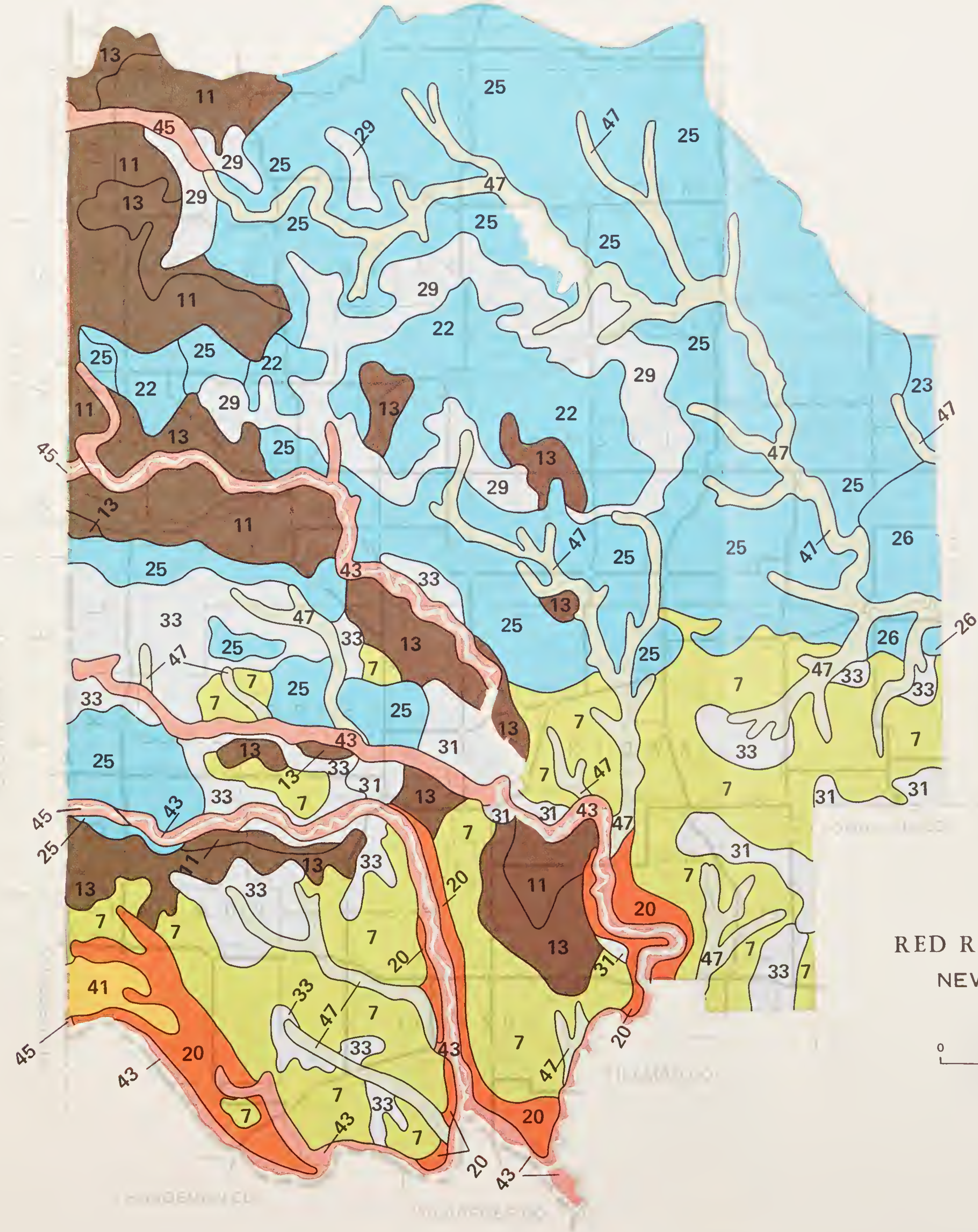
LEGEND

- Primary Road
- Interstate Highway
- Federal Highway
- State Highway
- Town or City
- County Seat
- City Limits
- State Line
- County Line
- Drainage
- Basin Boundary



VICINITY MAP

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NEW MEXICO, TEXAS AND OKLAHOMA

0 10 20 30 40

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Sheet 4 of 6 JUNE 1975 BASE 4-R-32846-1-A

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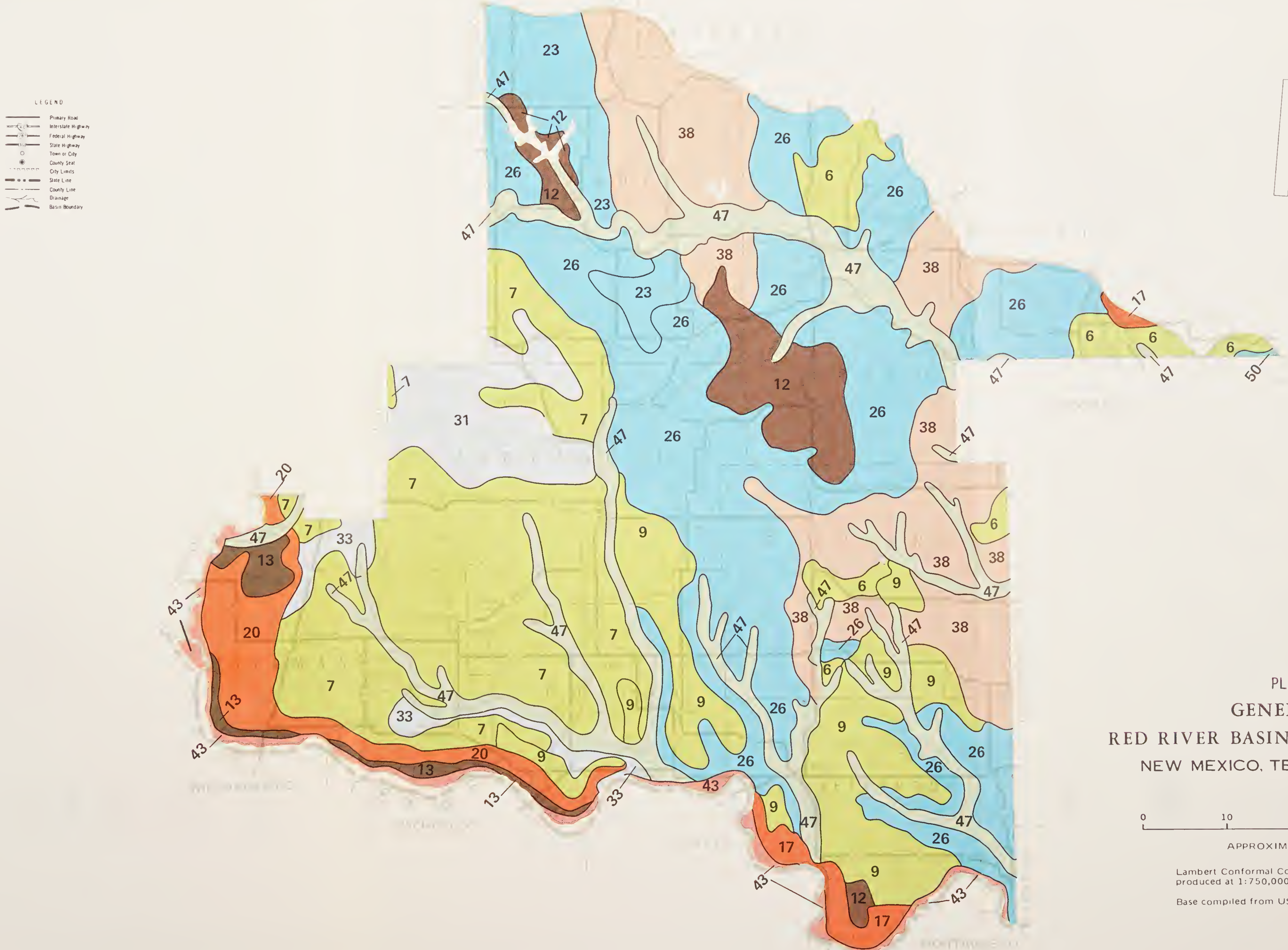

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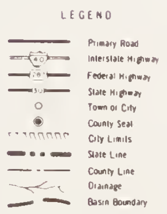

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0 10 20 30 40

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Sheet 6 of 6 JUNE 1975 BASE 4-R-32846-1-A

LAND RESOURCE AREAS

The Red River Basin Above Denison Dam contains portions of seven land resource areas. They are Southern High Plains, Central Rolling Red Plains, Central Rolling Red Prairies, Cross Timbers, Grand Prairie, Texas Blackland Prairies, and Southern Coastal Plains, Plate 4-6. A land resource area is a geographic delineation characterized by similarity of soils, topography, climate, and vegetation, as shown in Table 4-2. These characteristics greatly influence the use and conservation treatment necessary to protect resources and sustain an economic level of agricultural production.

Table 4-3 shows the acreage and percentage of each land resource area.

The Southern High Plains (77) is a relatively level alluvial plain beginning at the western tip of the study area and extending eastward to the caprock covering about 3.9 million acres. The landscape is punctuated by numerous depressions known as playas. The deep loamy, calcareous soils support an intensive agricultural community which produces wheat, cotton, grain sorghum, and sugar beets. There are 2.6 million acres being cultivated with 50 percent being irrigated. The remainder of the area is devoted to ranching. Almost all this LRA is arable.

The Central Rolling Red Plains' (78) soils have slightly leached brown or reddish brown surface horizons with loamy to clayey subsoils. It covers about 15 million acres beginning at the caprock in Texas and extending eastward to the east side of the Wichita Mountains. The topography has a gentle southeast slope with elevation ranging from 750 to 3,000 feet. Valleys are fairly broad and shallow. Prominent granite knobs and ridges rise from this plain in places as much as 1,000 feet to form the Wichita Mountains.

Small grain-cattle farming is the main enterprise. The main crops are wheat, grain sorghums, and cotton. The dominant native vegetation on this rangeland is little bluestem, big bluestem, sideoats grama, blue grama, and buffalograss. Rolling sandy areas are mostly in ranches which grow enough sorghum and alfalfa to overwinter medium sized cow herds.

The Central Rolling Red Prairies (80) is an area of smooth to rolling land named as a result of the dominantly red sedimentary rocks of the "Red Beds" formation. It covers an area of about 2.7 million acres. Local relief is seldom

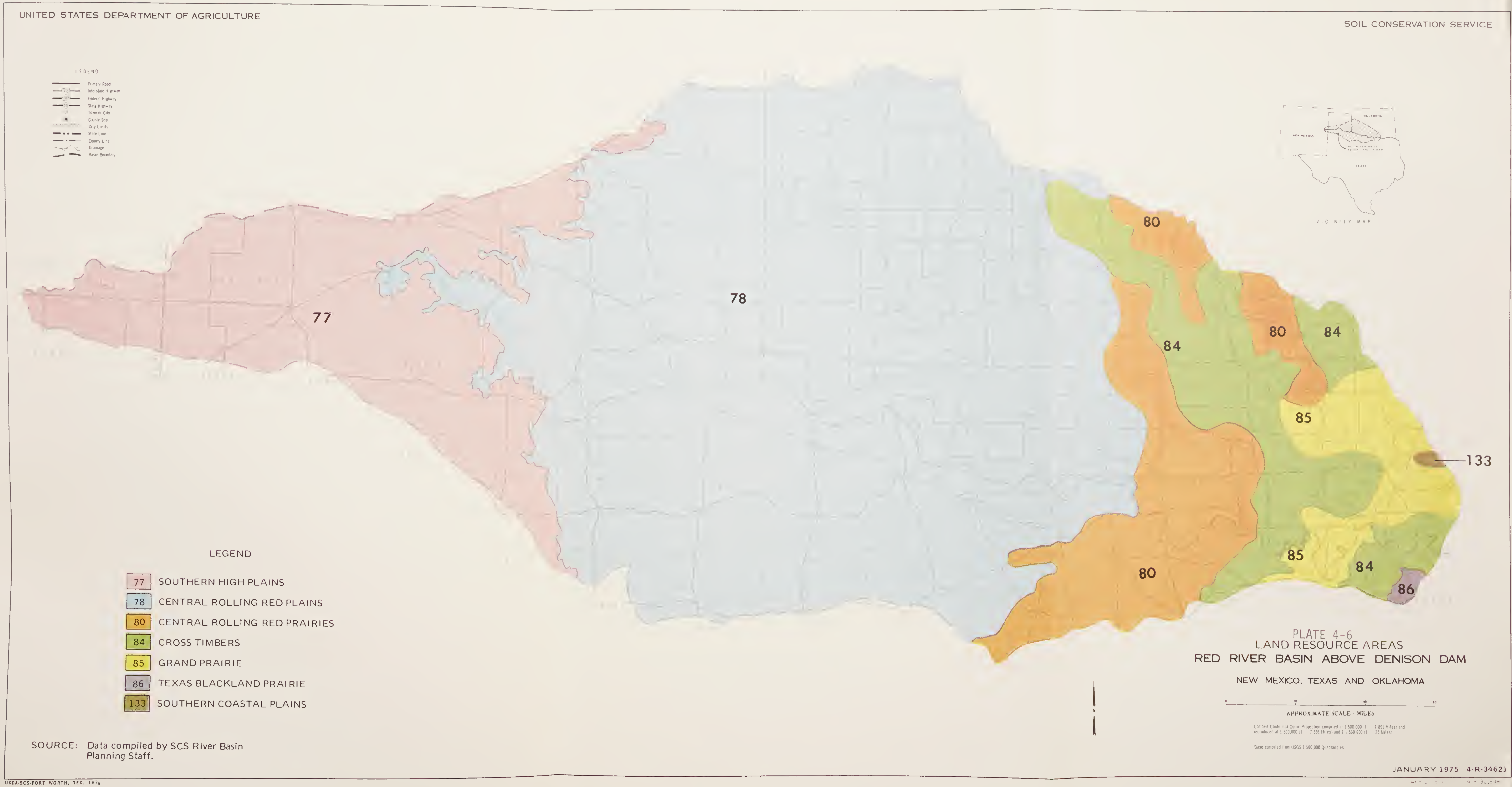
TABLE 4-2

General Characteristics of Land Resource Areas

Red River Basin Above Denison Dam

Land Resource Area	Elevation and Topography	Soils and Vegetation	Water	Land Use and Major Crops
77 Southern High Plains	3,000 ft. msl to 4,500 ft. msl Nearly level plain, punctuated by numerous intermittent depressions which lie some 5-30 ft. below surrounding plain.	Alkaline, brownish clay loam in northern part to reddish sandy loam in southern section. Caliche layers at 0-5 feet, sideoats grama, blue grama, and mesquite dominate native areas.	Average annual rainfall 15 to 20 inches, moisture conservation essential. Irrigation from ground water.	Sixty-nine percent in cropland, wheat, grain sorghum, cotton, and sugar beets provide most crop income. Irrigation water limiting production constraint.
78 Central Rolling Red Plains	750 ft. msl to 3,000 ft. msl Generally rolling but, also significant area nearly level & other portions rough with steep slopes.	Reddish, loamy, or sandy texture in western part, and clayey in eastern section. Significant plants are buffalograss, mesquite, redberry, juniper, & prickly pear.	Average annual rainfall ranges from 20 to 28 inches.	Seventy percent of inventory land used as rangeland. Wheat, grain sorghum & forage sorghums are principal crops
80 Central Rolling Red Prairies	750 ft. msl to 1,250 ft. msl Very gently sloping to undulating, well dissected.	Moderately deep silt loam or clay loam. Midgrass prairie association containing Texas wintergrass, threeawns, mesquite, lotebush, condalia, & prickly pear.	Average annual rainfall ranges from 27 to 33 inches.	Eighty-four percent of the inventory land is used as rangeland. Cotton, grain sorghum, and wheat are major crops.
84 Cross Timbers	500 ft. msl to 1,250 ft. msl Gently rolling to strongly rolling.	Sandy surface with clay and clay loam subsoil. Post oak-blackjack oak savannah with bluestems, sand dropseed, & red lovegrass.	Average annual rainfall ranges from 32 to 38 inches.	No predominant land use. Peanuts, cotton, and small grains are the most significant crops.
85 Grand Prairie	500 ft. msl to 1,250 ft. msl Gently sloping to rolling.	Clay or clay loams with outcrops of limestone. Buffalograss, threeawns, and mesquite with post oak and blackjack oak dominating shallow sloping areas.	Average annual rainfall 34 inches.	No predominant land use. Peanuts, wheat, and forage sorghum, are major crops.
86 Texas Blackland Prairie	500 ft. msl to 750 ft. msl Nearly level with steep slopes found along streams.	Dark clay soils, bluestems, threeawns, & Texas wintergrass with scattering live oak, elm, & hackberry.	Average annual rainfall is 38 inches.	About half the area is in cropland. Cotton, grain sorghum, & wheat are major crops.
133 Southern Coastal Plains	500 ft. msl to 750 ft. msl Undulating to sloping.	Sandy loam soils. Post oak and blackjack dominate.	Average annual rainfall ranges from 38 to 40 inches.	Area devoted to cattle raising with improved pastures of bermudagrass and clover.

Source: SCS


UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
77
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133
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84
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86
LEGEND
77 SOUTHERN HIGH PLAINS
78 CENTRAL ROLLING RED PLAINS
80 CENTRAL ROLLING RED PRAIRIES
84 CROSS TIMBERS
85 GRAND PRAIRIE
86 TEXAS BLACKLAND PRAIRIE
133 SOUTHERN COASTAL PLAINS
SOURCE: Data compiled by SCS River Basin Planning Staff.
PLATE 4-6
LAND RESOURCE AREAS
RED RIVER BASIN ABOVE DENISON DAM
NEW MEXICO, TEXAS AND OKLAHOMA
APPROXIMATE SCALE - MILES
VICINITY MAP
JANUARY 1975 4-R-34621
USDA-SCS-FORT WORTH, TEX. 1976

TABLE 4-3

Land Resource Areas by States

Red River Basin Above Denison Dam

Land Resource Area	Oklahoma		Texas		Basin	
	Percent	Acres	Percent	Acres	Percent	Acres
Southern High Plains (77)	-	-	15.6	3,912,000	15.6	3,912,000
Central Rolling Red Plains (78)	25.2	6,295,910	35.0	8,734,400	60.2	15,030,310
Central Rolling Red Prairies (80)	6.3	1,568,610	4.4	1,095,300	10.7	2,663,910
Cross Timbers (84)	7.9	1,976,880	1.2	298,700	9.1	2,275,580
Grand Prairie (85)	3.5	870,260	0.6	142,300	4.1	1,012,560
Blackland Prairie (86)	-	-	0.2	42,700	0.2	42,700
Southern Coastal Plains (133)	0.1	32,230	-	-	0.1	32,230
TOTAL	43.0	10,743,890	57.0	14,225,400	100.0	24,969,290

Source: SCS

extreme in the Reddish Prairie and probably averages only 100 feet from stream to divide, in the smoother portion. The more rolling areas are used mostly for small grains - cattle farming with wheat being the main cash crop. On sandy soils, cotton and peanuts are grown.

In the eastern part, tame Bermudagrass pasture is found along with native grasses and alfalfa, used for winter hay. The main recreational use of the area is for bird and small game hunting.

The Cross Timbers (84) is a wooded area of rolling to hilly sandstone uplands covering about 2.2 million acres. Soils are generally light colored, moderately acid, and have reddish sandy clay loam subsoils. The topography is gently rolling to strongly rolling and consists of both dissected plateaus and long narrow sandstone ridges which are higher than the prairie plains. Most of the streams which are actively cutting have steep gradients and occupy narrow valleys in which there is only a small amount of tillable land. Most of the Cross Timbers area is now used for cattle production. Farm population has dwindled and the small farms are being consolidated into larger units which support grazing and forage production. Main crops grown are small grains, peanuts, and sorghums for feed. Lake Murray and Lake Texoma are popular recreational areas.

The Grand Prairie's (85) soils, developed from clayey shales, sandy clays, and limestones, are usually dark colored, leached, and acid. The topography is a gently sloping to rolling well dissected area covering about 1.0 million acres. The area includes hard limestones, sandstones, and shales of the Arbuckle Mountains which rise well above the plains around it. The primary agricultural use of these soils is for livestock - small grain farming. The major crops grown are small grains, grain sorghums for feed, and alfalfa for hay. Pasture programs based largely upon improved strains of Bermudagrass are becoming successful.

The Blackland Prairie (86) covers over 42,000 acres in the southeast corner of the study area. The topography is gently rolling to nearly level. The soils are dominantly deep or moderately deep calcareous clays. A few areas bordering streams have rather steep slopes. Over half of the LRA is in pastureland, primarily Bermudagrass. About 15,000 acres produce cotton, grain sorghum, and forage sorghums. Elm, hackberry, and pecan are found along the streams.

The Southern Coastal Plains' (133) soils are deep leached and strongly acid with a sandy loam upper horizon and a clay

loam to clay subsoil. Miller, Yahola, and Teller are the dominant soils covering 32,232 acres. This area comprises soils developed from marls, clays, and soft limestone on undulating to sloping topography. Post oak and blackjack dominate this area and it is mostly devoted to cattle raising. Improved pastures of Bermudagrass and clovers are being established.

LAND BASE

Current land use is divided into eight major use categories: cropland, pastureland, rangeland, forest land, other land, urban built-up, Federal, and water. Cropland and pastureland were further divided into irrigated and non-irrigated categories. Federal land includes military installations, national forests, national wildlife refuges, and other Federally-owned land outside of urban built-up areas.

Table 4-4 shows the current land use in Oklahoma and Texas and the basin.

FOREST LAND

SKY-LAB data classifies forest land into two general groups, that in the upland which consists primarily of post oak and blackjack; and those trees growing along the bottom lands or flood plain. Other scattered species such as mesquite, shinnery oak, elm, hackberry, juniper, and many others make up woody vegetation of such poor quality, they are not considered useful for a forest product. Many acres of these brush types do provide habitat for various wildlife species and range for domestic livestock. The wildlife aspect of this study is being analyzed separately. These lower quality woody species groups will be accounted for under that portion of the study. The segment of the same land which is used for domestic livestock will also be discussed in another section of this report. Potentials for development of the post oak-blackjack forests and bottom land forests will be covered in this chapter. An evaluation of forest limitations will also be expanded in this chapter.

The forest resource base in this study is confined to an analysis and evaluation of the post oak-blackjack and bottom land hardwood forests. SKY-LAB photography was transferred to maps in an effort to identify, locate, and determine forest acreages. That procedure also classified other types of woody vegetation such as shinnery oak and mesquite.

<u>Species Uses:</u> Bottom land forests occupy less than a quarter of the 876,000 acres of forest land in the basin. Although bottom land

TABLE 4-4

Current Major Land Use Distribution

Red River Basin Above Denison Dam

Land Use	Current Acres		
	Oklahoma	Texas	Basin Total
Nonirrigated Cropland	3,281,100	3,773,300	7,054,400
Irrigated Cropland	157,400	1,393,600	1,551,000
Rangeland	4,174,800	7,994,200	12,169,000
Nonirrigated Pastureland	926,600	204,000	1,130,600
Irrigated Pastureland	34,100	62,400	96,500
Forest Land	768,300	108,300	876,600
Other Land	281,440	104,200	385,640
Urban built-up	552,350	295,900	848,250
Federal	257,250	41,050	298,300
Water	310,550	248,450 1/	559,000
Total	10,743,890	14,225,400	24,969,290

1/ Includes lakes, ponds, and playas.

Source: River Basin Staff, SCS

species are found in all LRA's, except the Southern High Plains, both their quality and incidence are higher in the eastern half of the basin. The better species found are pecan, walnut, cottonwood, oaks, maple, and ash.

Over 600,000 acres are post oak-blackjack oak. This type of cover (the Cross Timbers Vegetative Region) occupies much of the uplands in the eastern part of the basin (Land Resource Areas Numbers 80, 84, and 85).

The almost forty lumber and wood products establishments operating in this basin are dependent on two forest types: post oak-blackjack oak and bottom land species such as pecan, walnut, and miscellaneous oaks. Post oak-blackjack is a poor quality timber type at best. Few wood-using industries can prosper from this resource. Some of the marginal industries are pallet factories, charcoal plants, crosstie manufacturers, handle makers, and firewood suppliers.

The bottom land species are constantly being high-graded (crop trees being harvested prematurely with poor trees being left) for pulpwood, ties, and other submarginal products. Conversely, the few valuable mature trees are often cut for pulp and firewood along with the low value trees. The result is a residual stand having the few remaining trees of value extremely scattered and thus unmanageable.

Forestry authorities in both Texas and Oklahoma are well aware of this situation but hesitate to suggest accelerated timber management for fear that expansion of harvesting operations would encourage increased range use which would result in accelerated erosion and further site deterioration. A better option, they feel is to manage these post oak-blackjack forests for wildlife habitat and erosion prevention rather than timber. Such management would tend to preserve the existing vegetative cover.

The Black Kettle National Grassland district in the basin, is publically owned and Federally administered by the National Forest System. Few holdings in the basin are managed for timber growth and production. Even the National Grasslands are used primarily for watershed management and livestock grazing.

MINERAL RESOURCES

Oil and natural gas are the most important minerals in the basin. Drilling activity is heavy. New discoveries have been made in the Anadarko region. About 32 million barrels of crude petroleum were produced in the Texas portion of the basin in 1974.

Sand and gravel deposits are located throughout the basin. These materials are used primarily in construction work.

Gypsum is being produced for wallboard and for agricultural uses in several places. There are many areas that could be developed.

Stone products such as monuments from granite and limestone aggregate for concrete are being quarried from several locations.

Clay and shale are mined in several areas and used in brick and tile. Bentonite for use in drilling muds is mined in Briscoe County. Refractory clay is mined in Clay County and structural sandstone in Wichita County. Volcanic ash for use as an abrasive is mined in Collingsworth and Dickens counties.

Copper is being mined from open pits in an area near Creta, Oklahoma. Other areas have been tested in the flower pot shale. The ore is low grade and production depends on the price of copper.

Salt is produced in several locations in western Oklahoma. Other areas could be developed if the demand increased.

Beds of medium and high-volatile bituminous coal of commercial value are present in Archer, Clay, and Montague counties, but are not mined at present.

Other minerals in small amounts such as silver hermatile, and uranium are found in low grade ores and have not been produced.

HISTORICAL AND ARCHEOLOGICAL

Approximately 3,000 archeological sites are listed in the Red River Basin Above Denison Dam. The Oklahoma Archeological Survey lists 1,800 of these for Oklahoma with a tentative classification for 850 of these. The Texas portion has 1,077 recorded archeological sites. There are many unrecorded sites in the basin.

An inventory has been made of 108 historical sites in the Texas portion of the basin. The Oklahoma portion has 20 historical sites included in the National Historic Register.

The historical or archeological inventories are not complete. An attempt was made to indicate significant sites, and hopefully, will further emphasize the importance of preserving our historic past.

Further details of site occurrence and type are found in the special reports of the Archeological Perspective of the Oklahoma portion and the Historical and Archeological Resources of the Texas portion of the basin.

FISH AND WILDLIFE

The Red River Basin Above Denison Dam contains a diversity of habitat for fish and wildlife, ranging from the plains in the west to the oak forest in the east.

Aquatic Resources: This aquatic inventory includes lakes, rivers, streams, and wetlands. There are about 392,000 surface acres of lakes and ponds in the study area. According to "Wetlands of the United States" (U. S. Department of the Interior, 1971) the following seven types of wetlands occur within the basin, Table 4-5.

TABLE 4-5

Wetlands

Red River Basin Above Denison Dam

Type	Description	Oklahoma	Texas
1	Seasonal flooded basins or flats	Along Major rivers and tributaries	Along major playas in Southern High Plains LRA
2	Inland fresh meadows	Along major rivers and tributaries	-
3	Inland shallow fresh meadows	Around Lake Texoma	Hemphill and Wheeler Cos.
4	Inland deep fresh meadows	Around Lake Texoma	Hemphill and Wheeler Cos.
5	Inland open fresh water	Scattered throughout	Scattered thoughout
6	Shrub swamps	Around Lake Texoma	-
7	Wooded swamps	Around Lake Texoma	-

Source: River Basin Staff, SCS

Springs, which are significantly important, occur within the counties of Texas adjacent to the Texas-Oklahoma boundary and in the Arbuckle Mountains (Chickasaw National Recreational Area) and in the Wichita Mountains of Oklahoma.

Fishery Inventory: The fishery habitat includes 345,950 surface acres of ponds, playas, and lakes and 3,752 miles of streams in the basin.

The sport fishery habitat supports a total standing crop of approximately 165 million pounds, Table 4-6. Main sport fish species are white bass, largemouth bass, spotted bass, striped bass, walleye, northern pike, crappie, channel catfish, flathead catfish, blue catfish, and sunfish. The sunfish include bluegill, redear, green, warmouth, spotted and longear.

Rough fish are carp, buffalo fishes, gizzard shad, carpsuckers, freshwater drum, and bullhead. There are also over 40 species of minnows in the basin's streams.

Wildlife Inventory: A habitat map, Plate 4-7, has been prepared showing that open rangeland and cropland are the dominant land uses in the basin, while upland and bottom land woody cover, in the west and central areas is limited and often critical. Upland blackjack-post oak forests are abundant in the east, but even here bottom land forests are scarce enough to limit some wildlife species.

This habitat map shows the major habitat types. Types include cultivated land and grassland, as well as the delineations of the key woody plant species that form a canopy of 20 percent or more.

The wildlife species have been classified into Game, Waterfowl, Furbearers, and Others to facilitate their presentations.

Game Species: Game species occurring in the study area include the white-tailed deer, Rio Grande turkey, mule deer, aoudad, pronghorn, ring-necked pheasant, lesser prairie chicken, scaled quail, bobwhite, mourning dove, fox squirrel, ducks, and geese.

The density of these species are shown in Table 4-7. A map has been prepared for the following species: white-tailed deer and Rio Grande turkey - Plate 4-8; quail (includes both scaled and bobwhite) Plate 4-9; and mourning dove - Plate 4-10, to show their location and relative abundance.

TABLE 4-6

Fishery Resources

Red River Basin Above Denison Dam

	Oklahoma	Texas	Total
Fishery Habitat (surface acres)	197,550	148,400	345,950
Average Standing Crop (lbs./acres)	620	285	499
Total Standing Crop (lbs.)	122,684,700	42,323,900	165,000,100
Average Harvest (lbs./acres)	22	42	31
Total Harvest (lbs.)	4,723,800	6,304,000	11,027,800
Existing Man-Days for Harvest (days)	2,352,700	13,862,300	16,215,000

Source: Oklahoma - Oklahoma Fisheries Research Lab of Oklahoma's Department of Wildlife Conservation.
Texas - Compiled by River Basin Work Group (Texas) from formulas developed by Robert M. Jenkins.

TABLE 4-7

Game Species

Red River Basin Above Denison Dam

	HABITAT (acres)			DENSITY (acres/animal)			TOTAL FALL POPULATION		
	Oklahoma	Texas	TOTAL	Oklahoma	Texas	TOTAL	Oklahoma	Texas	TOTAL
White-Tailed Deer	1,418,720	2,410,410	3,829,130	125	570	246	11,380	4,200	15,580
Rio Grande Turkey	1,418,720	1,253,480	2,672,200	166	130	150	8,410	9,430	17,340
Quail	5,419,660	12,616,250	18,035,910	18	14	15	294,900	923,120	1,218,020
Mourning Dove	5,419,660	14,418,460	19,838,126	22	7	9	245,210	1,950,360	2,195,570
Squirrel	472,910	991,450	1,464,360	6	20	12	74,480	48,930	123,410
Mule Deer 1/		727,280	727,280		210	210		3,430	3,430
Aoudad 1/		543,350	543,350		370	370		1,480	1,480
Pronghorn 1/		27,260	27,260		450	450		60	60
Ring-Necked Pheasant 1/		1,239,770	1,239,770		26	26		47,850	47,850
Lesser Praire Chicken 2/		375,330	375,330		60	60		6,250	6,250
Duck 2/		135,370	135,370					677,850	677,850
Geese 2/		135,370	135,370					135,370	135,370

1/ These species are only found in Texas.

2/ Information not available.

Source: SCS

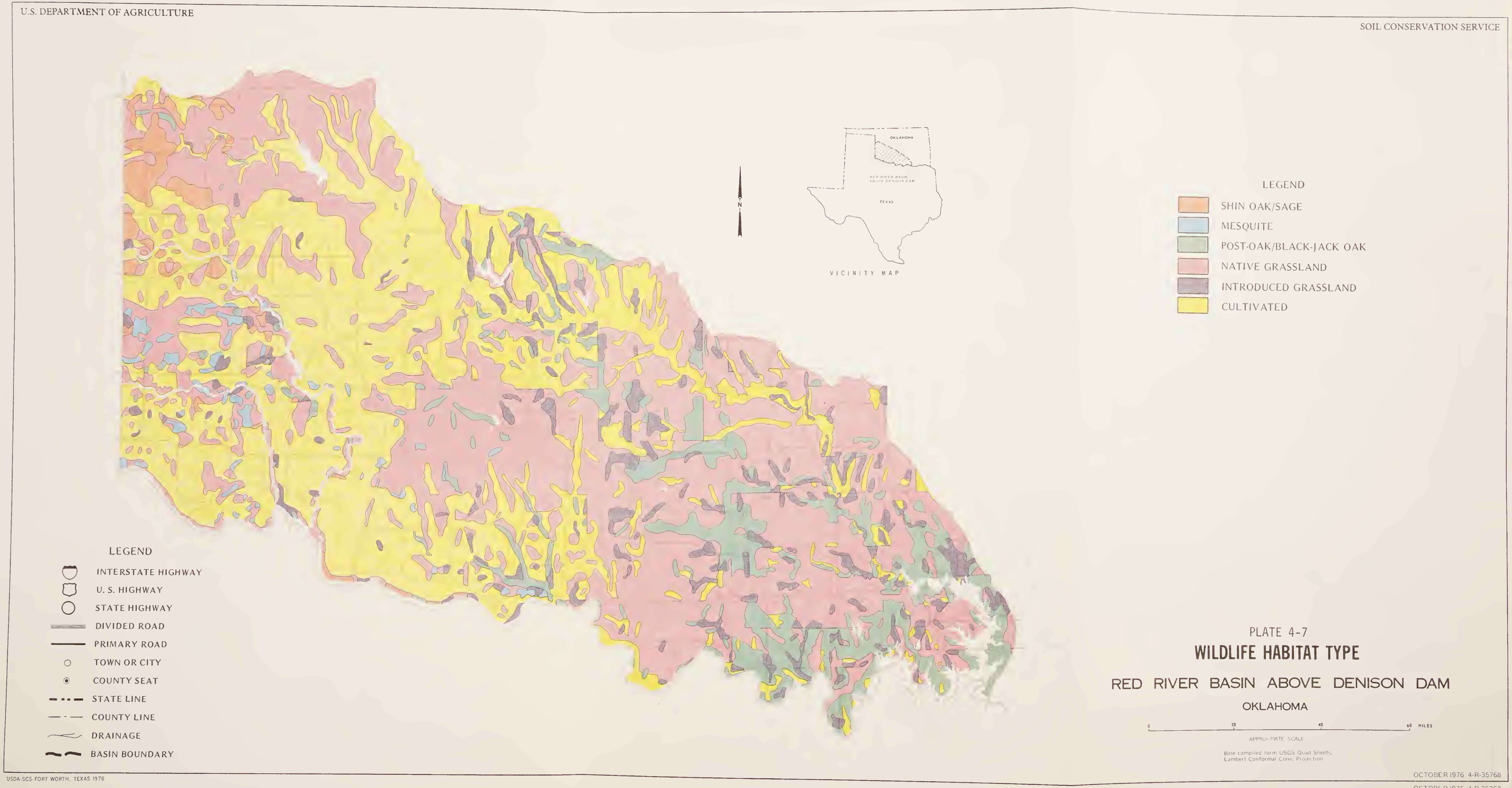
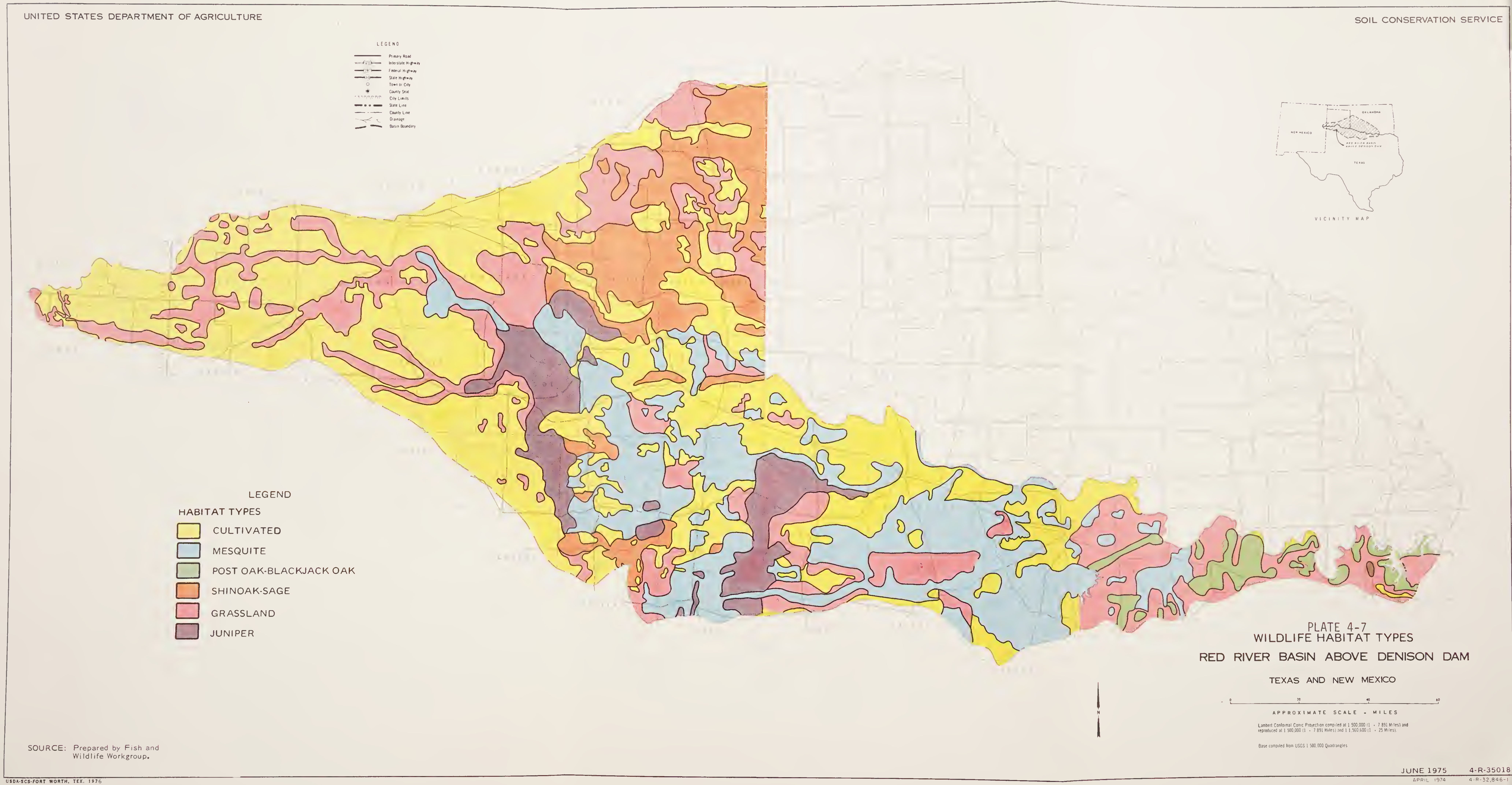


PLATE 4-7

WILDLIFE HABITAT TYPE

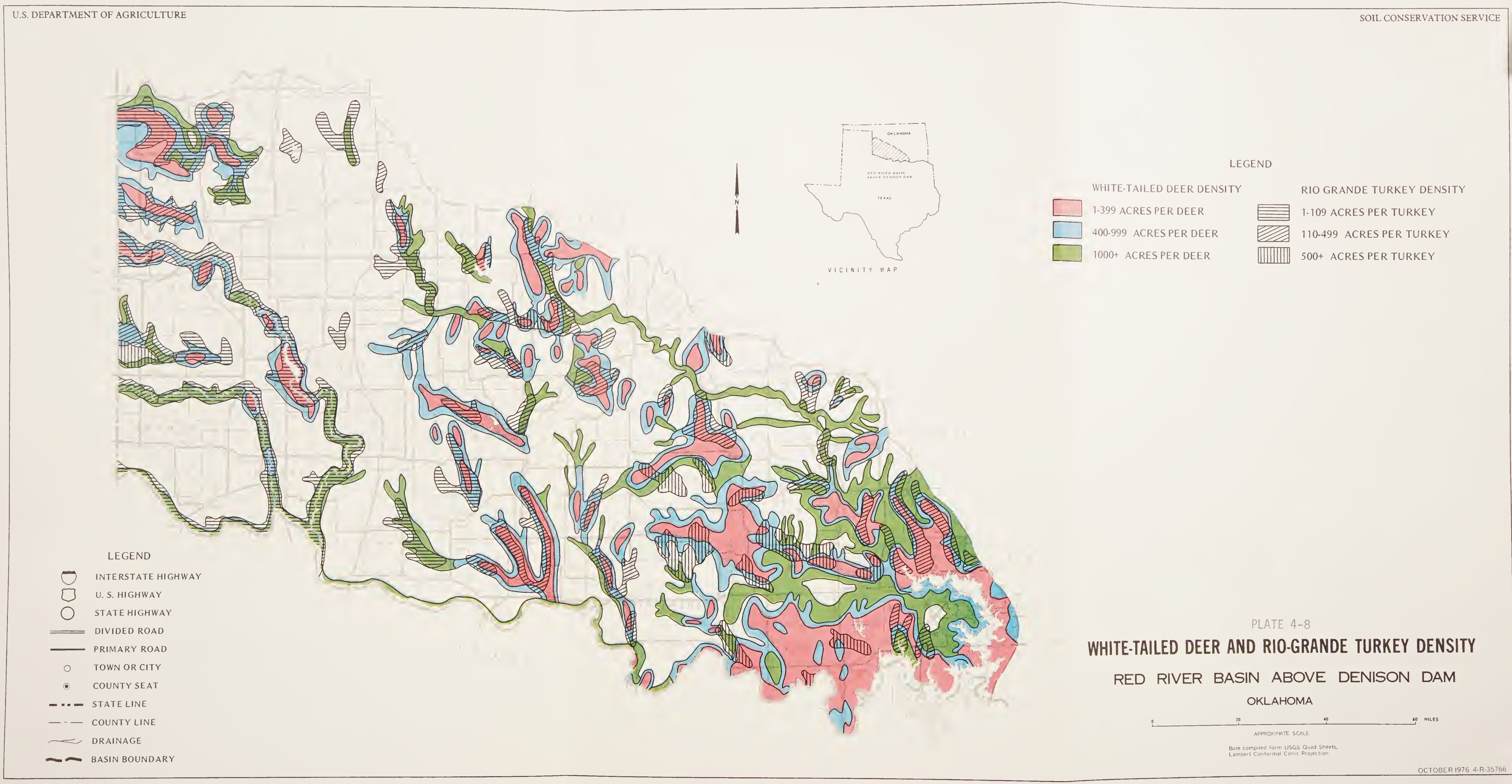
RED RIVER BASIN ABOVE DENISON DAM

OKLAHOMA



USDA-SCS-FORT WORTH, TEX. 1976

APRIL 1974 4-R-32,846-1


U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
OKLAHOMA
TEXAS
VICINITY MAP
N
LEGEND
WHITE-TAILED DEER DENSITY
1-399 ACRES PER DEER
400-999 ACRES PER DEER
1000+ ACRES PER DEER
RIO GRANDE TURKEY DENSITY
1-109 ACRES PER TURKEY
110-499 ACRES PER TURKEY
500+ ACRES PER TURKEY
LEGEND
INTERSTATE HIGHWAY
U. S. HIGHWAY
STATE HIGHWAY
DIVIDED ROAD
PRIMARY ROAD
TOWN OR CITY
COUNTY SEAT
STATE LINE
COUNTY LINE
DRAINAGE
BASIN BOUNDARY
PLATE 4-8
WHITE-TAILED DEER AND RIO-GRANDE TURKEY DENSITY
RED RIVER BASIN ABOVE DENISON DAM
OKLAHOMA
0 20 40 60 MILES
APPROXIMATE SCALE
Base compiled form USGS Quad Sheets,
Lambert Conformal Conic Projection
OCTOBER 1976 4-R-35766

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

PLATE 4-8

WHITE-TAILED DEER AND TURKEY

RED RIVER BASIN ABOVE DENISON DAM

TEXAS AND NEW MEXICO

SOURCE: Prepared by Fish and Wildlife Workgroup.

JUNE 1975 4-R-34972

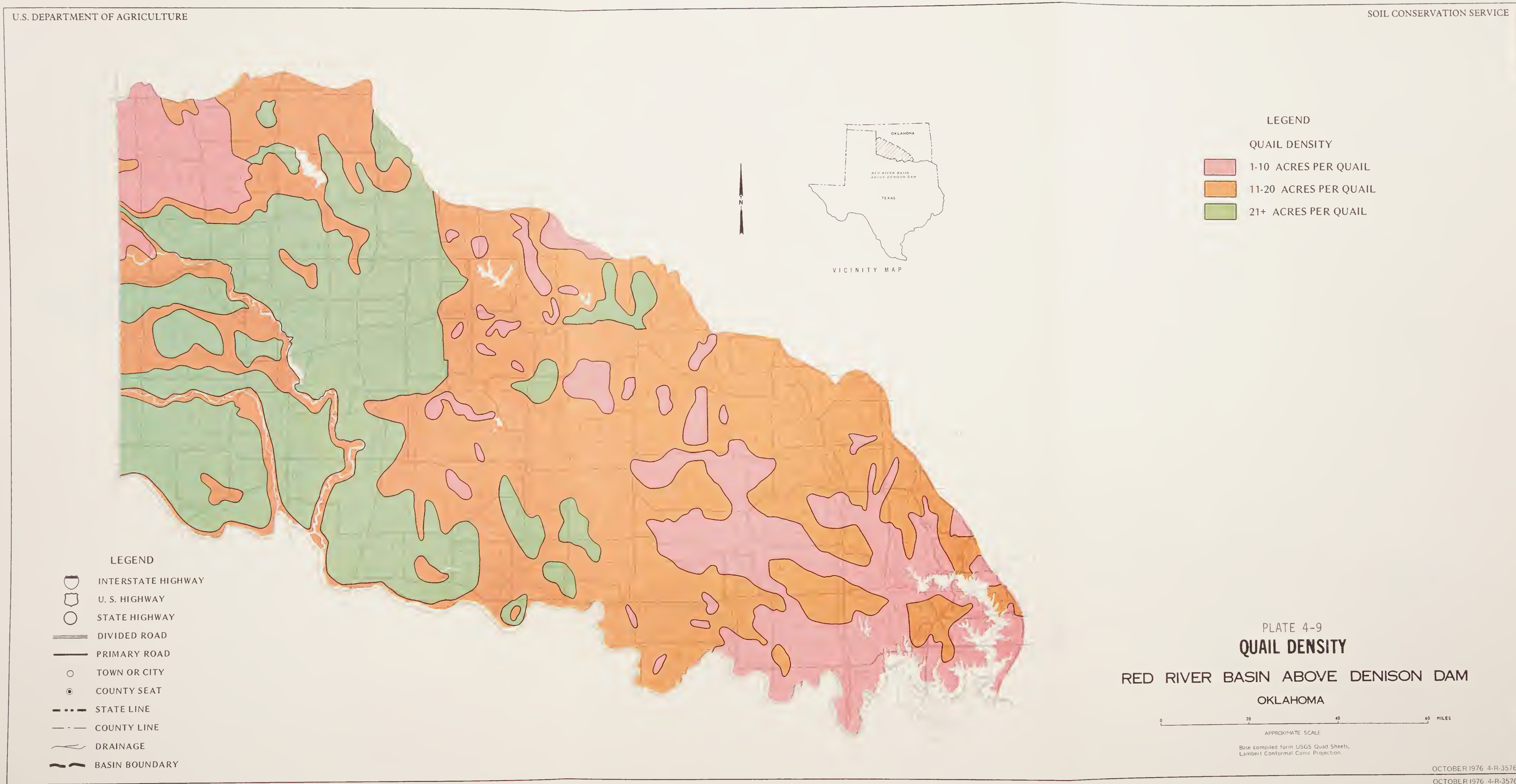


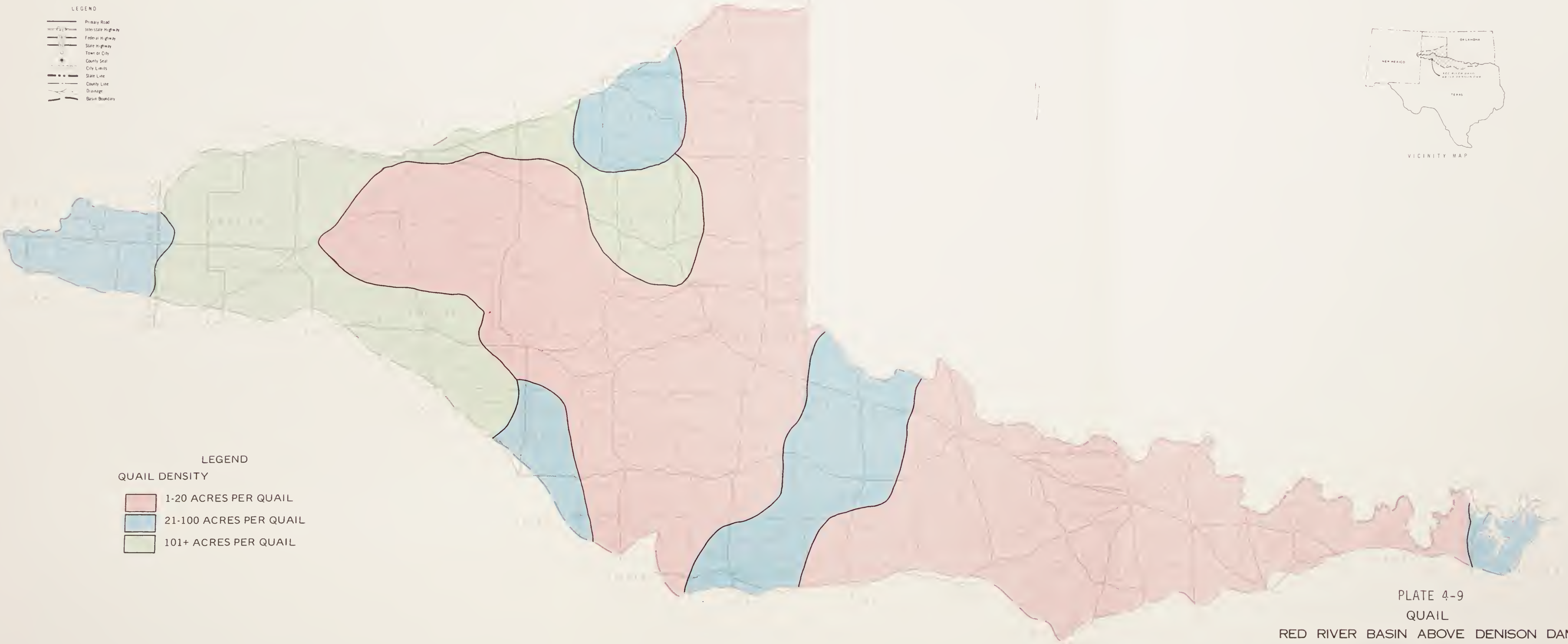
PLATE 4-9
QUAIL DENSITY
RED RIVER BASIN ABOVE DENISON DAM
OKLAHOMA

USDA-SCS-FORT WORTH, TEXAS 1976

OCTOBER 1976 4-R-35763

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE



LEGEND

QUAIL DENSITY

- 1-20 ACRES PER QUAIL
- 21-100 ACRES PER QUAIL
- 101+ ACRES PER QUAIL

PLATE 4-9

QUAIL

RED RIVER BASIN ABOVE DENISON DAM

TEXAS AND NEW MEXICO

0 20 40 60

APPROXIMATE SCALE–MILES

Lambert Conformal Conic Projection compiled at 1 500,000 (1 - 7 891 Miles) and reproduced at 1 500 000 (1 - 7 891 Miles) and 1 1,560,600 (1 - 25 Miles)

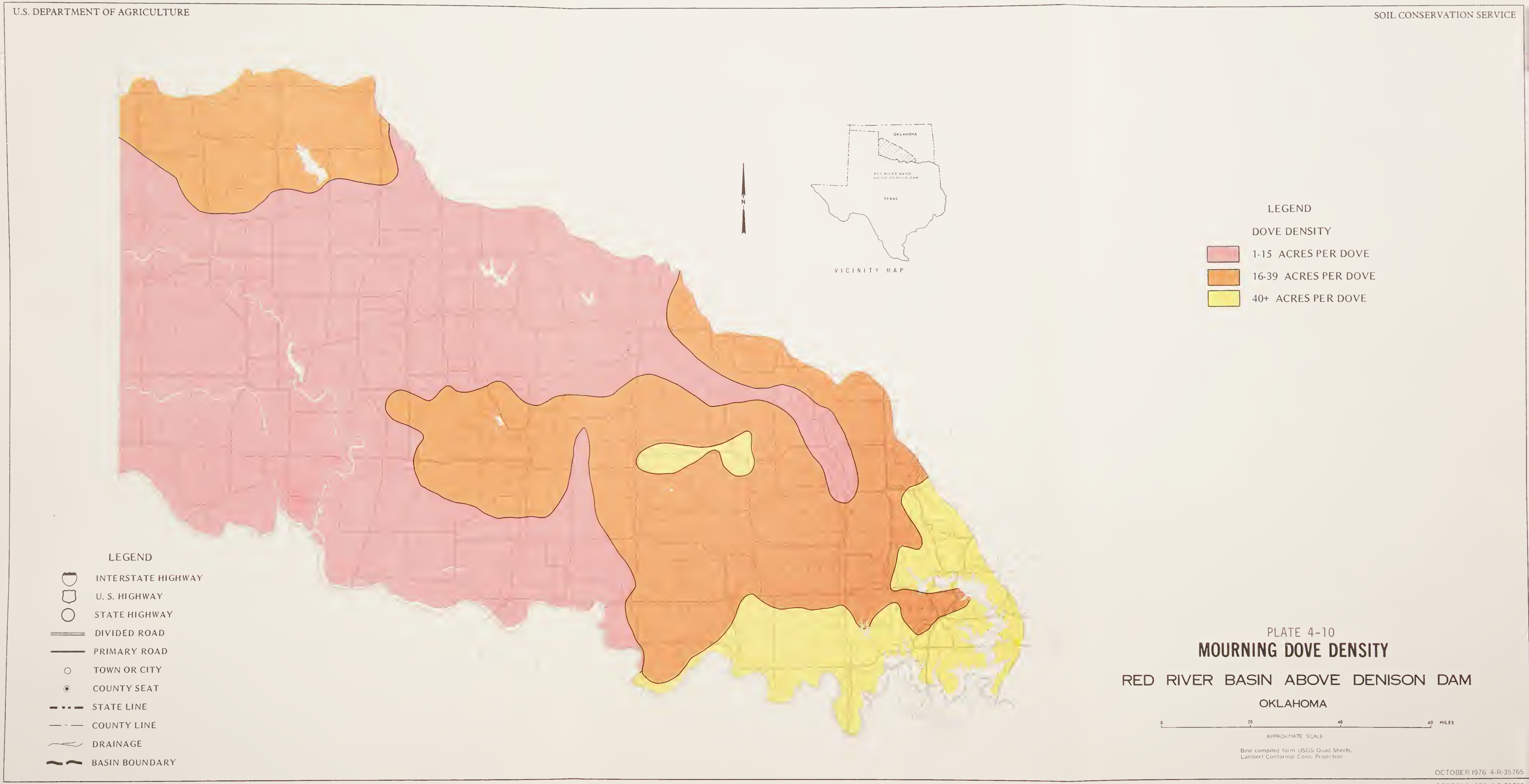
Base compiled from USGS 1 500,000 Quadrangles

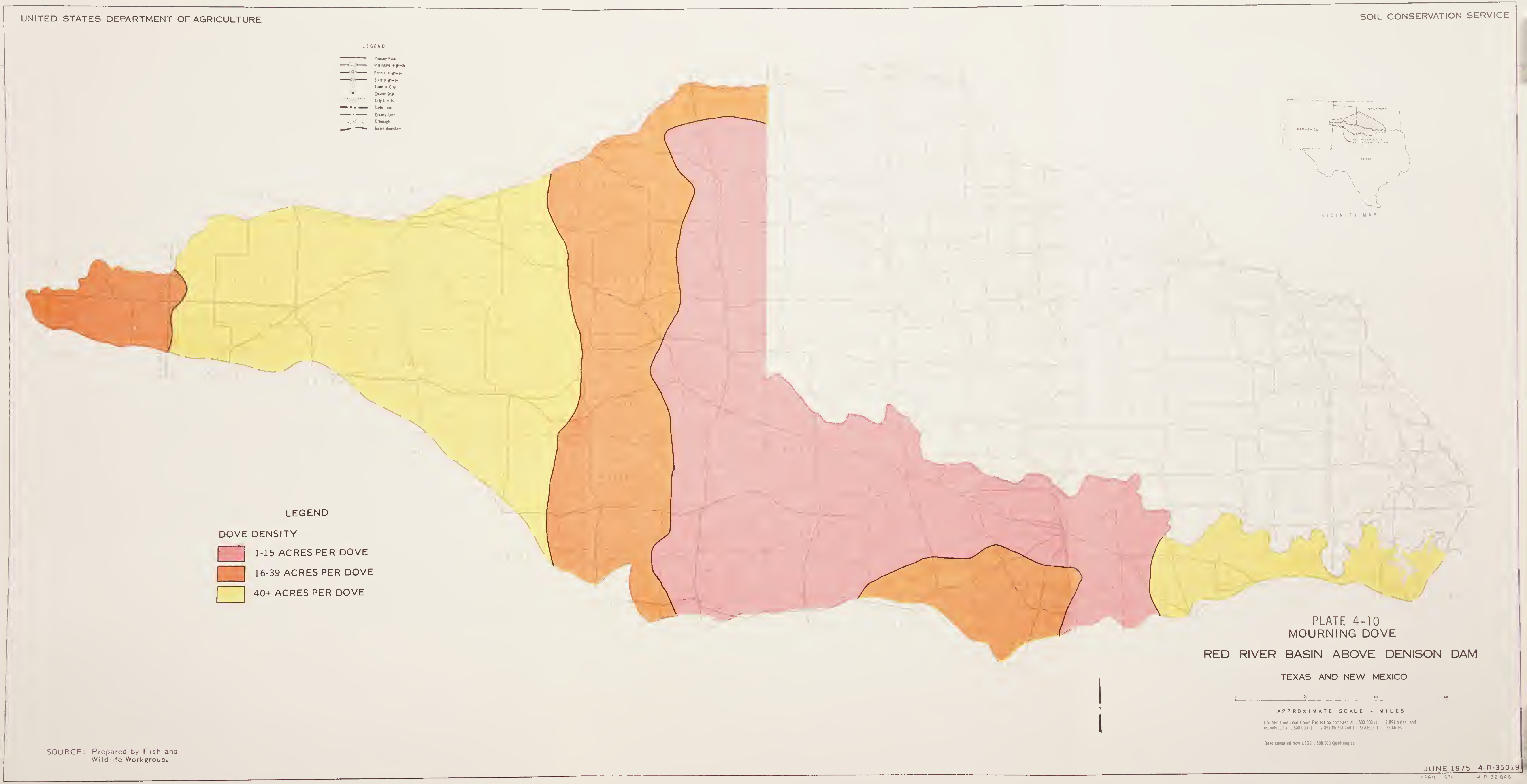
SOURCE: Prepared by Fish and Wildlife Workgroup.

JUNE 1975 4-R-35020

APRIL 1974 4-R-32,846-1

USDA-SCS-FORT WORTH, TEX. 1975


U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
OKLAHOMA
RED RIVER BASIN ABOVE DENISON DAM
TEXAS
VICINITY MAP
N
LEGEND
DOVE DENSITY
1-15 ACRES PER DOVE
16-39 ACRES PER DOVE
40+ ACRES PER DOVE
LEGEND
INTERSTATE HIGHWAY
U. S. HIGHWAY
STATE HIGHWAY
DIVIDED ROAD
PRIMARY ROAD
TOWN OR CITY
COUNTY SEAT
STATE LINE
COUNTY LINE
DRAINAGE
BASIN BOUNDARY
PLATE 4-10
MOURNING DOVE DENSITY
RED RIVER BASIN ABOVE DENISON DAM
OKLAHOMA
0 20 40 60 MILES
APPROXIMATE SCALE
Base compiled form USGS Quad Sheets,
Lambert Conformal Conic Projection
OCTOBER 1976 4-R-35765



APRIL 1974 4-R-32,846-1

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Additional information concerning these species can be found in "Special Report Fish and Wildlife Resources", for Oklahoma and Texas.

Waterfowl: The Red River Basin is located in the main migration route of the Central Flyway. Many birds rest here during migration but relatively few remain over the winter. Mallard, pintail, blue-winged teal, green-winged teal, cinnamon teal, baldpate, canvasback, redhead, gadwall, scaup, ruddy duck, golden-eye, bufflehead, wood duck, ring-necked duck, shoveler, mergansers, blue geese, Canada geese, and white-fronted geese are all found in the basin. The whooping crane and sandhill crane migrate across the basin, along with a variety of shorebirds. Several species of herons and egrets are found year round in well-vegetated shallow-water areas. Primary waterfowl habitat in the basin is pond and playas in the west and the lakes in the east.

Furbearers: Furbearing species are beaver, mink, nutria, muskrat, raccoon, striped skunk, spotted skunk, long-tailed weasel, red fox, gray fox, swift fox (kit fox), coyote, badger, bobcat, and ringtail.

Beaver range and population are increasing in Oklahoma due primarily to the hundreds of small water impoundments, whereas the population in Texas only occurs along Washita River, Sweetwater Creek, and Gageby Creek in Hemphill and Wheeler counties, Wichita River in Wichita County, and in some water impoundments in Montague, Cooke, and Grayson counties.

The coyote, raccoon, striped skunk, and opposum are common throughout the basin whereas the other furbearers are more restricted in their range.

Other Species: Mammals found throughout the study area are armadillo, many species of rodents, and eight species of bats. The black-tailed prairie dog and black-footed ferret are inhabitants of the plains while porcupines occupy the western wooded areas.

Approximately 25 species of raptors and 130 species of songbirds may be found in the Red River Basin Above Denison Dam.

Threatened and Endangered Flora and Fauna: The following species, which occur in the basin, are listed in the Federal Register as being either threatened or endangered.

Plant Species	Status	Resident or Migrant
Correll's wildbush wheat	Threatened	-
Mammals		
Blackfooted ferrett	Endangered	-
Birds		
Southern baldeagle	Endangered	Resident
Eskimo Curlew	Endangered	Migrant
Whooping Crane	Endangered	Migrant
Peregine falcon	Endangered	Migrant

Other species of plants and animals are considered to be threatened or endangered by local State agencies and organizations. These species are discussed in the Special Reports on Fish and Wildlife Resources for Texas and Oklahoma.

RECREATION

Outdoor recreation in the Red River Basin Above Denison Dam is restricted by the quality and character of the terrain.

Although the terrain is varied from one end of the basin to the other, many broad expanses which occur throughout the basin are monotonous and offer very little promise for development. Potential sites for large reservoirs are nonexistent in the western portion of the basin, where water-oriented recreation is in great demand. However, many unique and natural areas are found within the study area and have a potential for providing excellent recreational opportunities if developed. The "Cap Rock Escarpment" is a prime example. Many of these areas remain undeveloped because of their location in sparsely populated areas away from heavily traveled tourist routes.

The major recreational areas and tourist attractions found in the basin are shown in Table 4-8 and their location is displayed on Plate 4-11.

Eight outdoor recreational activities were selected and inventoried as an overall portrayal of the recreational resources and the future outlook for recreational development in the basin. These activities are:

TABLE 4-8.

Major Recreational and Tourist Attractions

Red River Basin Above Denison Dam

Map Number	Recreational and Tourist Attractions	Administrating Agency	State	County	Land Acres	Surface Acres of Water
1.	Lake McClellan National Grassland Park	U.S. Forest Service	TX	Gray	1044	405
2.	Buffalo Lake National Wildlife Refuge	U.S. Fish and Wildlife Service	TX	Randall	7677	1900
3.	Palo Duro Canyon State Park	Texas Parks and Wildlife Dept.	TX	Randall	15104	-
4.	Green Belt Dam Reservoir	Green Belt Municipal Water Supply District	TX	Donley	-	2025
5.	Mackenzie Reservoir	Mackenzie Municipal Water District	TX	Briscoe	-	900
6.	Lake Childress and Baylor Lake	City of Childress	TX	Childress	-	610
7.	Copper Breaks State Park (preliminary Development study)	Texas Parks and Wildlife Dept.	TX	Hardeman	1933	50
8.	Lake Pauline	West Texas Utility Co.	TX	Hardeman	600	400
9.	Santa Rosa Lake	Wagner Ranch	TX	Wilbarger	-	1500
10.	North Fork Buffalo Creek Reservoir	Wichita County Water Control & Improvement District	TX	Wichita	-	1500
11.	Lake Kemp	City of Wichita Falls	TX	Baylor	-	16540
12.	Lake Diversion	City of Wichita Falls	TX	Baylor Archer	-	3419
13.	Lake Wichita	City of Wichita Falls	TX	Wichita Archer	120	2200
14.	Lake Kickapoo	City of Wichita Falls	TX	Archer	3570	6200
15.	Lake Arrowhead	City of Wichita Falls	TX	Clay	1525	16200
16.	Lake Arrowhead State Recreational Park	Texas Parks and Wildlife Dept.	TX	Clay	524	adjacent to Lake Arrowhead
17.	Nocona Lake (Farmers Creek Reservoir)	North Montague Water Supply District	TX	Montague	-	1470
18.	Moss Lake	City of Gainesville	TX	Cooke	-	1125
19.	Hagerman National Wildlife Refuge	U.S. Fish and Wildlife Service	TX	Grayson	11430	adjacent to Lake Texoma
20.	Lake Texoma	Corps of Engineers	TX & OK	Marshall Love, Cooke, Grayson	18061	89000
21.	Eisenhower State Recreation Park	Texas Parks and Wildlife Dept.	TX	Grayson	457	adjacent to Lake Texoma
22.	Lake Murray		OK	Carter Love	12496	5728
23.	Chickasaw National Recreational Area	Land National Park Service	OK	Murray	901	11
24.	Tishomingo National Wildlife Refuge	U.S. Fish and Wildlife Service	OK	Johnston	3160	-
25.	Arbuckle Reservoir	Bureau of Reclamation	OK	Murray	1120	2350
26.	Turner Falls	Okla. Parks Dept.	OK	Murray	30	-
27.	Lake Fuqua	City of Duncan	OK	Stephens	1145	1500
28.	Lake Lawtonka	City of Lawton	OK	Comanche	-	2000
29.	Lake Ellsworth	City of Lawton	OK	Caddo Comanche	-	5000
30.	Wichita Mountains Wildlife Refuge	U.S. Fish and Wildlife Service	OK	Comanche	5900	-
31.	Lake Chickasha	City of Chickasha	OK	Caddo	350	2100
32.	Fort Cobb Recreation Area		OK	Caddo	1872	4098
33.	Mountain Park State Park	Okla. Park Dept.	OK	Kiowa	5000	-
34.	Quartz Mountain State Park		OK	Kiowa Greer	1172	5770
35.	Foss Reservoir State Park		OK	Custer	1749	3800
36.	Washita National Wildlife Refuge	U.S. Fish and Wildlife Service	OK	Custer	2400	-
37.	Black Kettle National Grassland	U.S. Forest Service	OK	Roger Mills	31000	-

Source: SCS

Camping - inventoried by camp site. A camp site is the location of an individual camping unit.

Picnicking - inventoried by a count of the number of sites.

Swimming - inventoried by area of swimming water in square yards.

Golf - inventoried by number of holes on a golf course. Therefore, a nine-hole golf course would count as nine holes.

Outdoor games - inventoried by acres. Oklahoma included playgrounds, baseball/softball, and football fields, rodeo arenas, and automobile race tracks, whereas Texas only included baseball fields and children's playgrounds.

The two types of trail activities inventoried in this report are horseback riding, and combined trails which include walking, hiking, nature study, and bicycling in Texas with hiking only measured in Oklahoma. All trails are inventoried by length of trails in miles.

Water sports - inventoried by suitable acres of water available for boating, boat fishing, and skiing.

The total number of facilities presently developed for each selected activity and the activity-days furnished by these facilities are shown in Table 4-9. An activity-day is defined as one recreational experience, regardless of duration, during any given day.

Fishing and hunting demands are separated from other recreational activities since they depend primarily on accessibility and preservation of natural resources which are privately owned than upon resource development.

The standards used to determine fishing and hunting demands were .25 acres per fisherman or 75 activity-days per year and two acres per hunter or seven activity-days per year.

WATER BASE

Freshwater as a natural resource is present in the study areas as rainfall, ground water, and streamflow from outside the area. Saline water is present as ground water and in some natural saline springs.

PLATE 4-11

Major Recreational and Tourist Attractions

RED RIVER BASIN
ABOVE DENISON DAM
Texas and Oklahoma

Source: USDA Soil Conservation Service, River Basin Staff, Texas and Oklahoma

TABLE 4- 9

Current Facilities and Activity Days by
Selected Recreational Activities

Red River Basin Above Denison Dam

Activity	Unit	Facilities			Activity Days		
		Oklahoma	Texas	Total	Oklahoma	Texas	TOTAL
					----------1000----------		
Camping	Sites	1,458	1,684	3,142	875	888	1,763
Picnicking	Sites	3,611	1,335	4,946	4,550	1,457	6,007
Swimming	1000 sq.yd.	26.4	52.7	79.1	1,426	2,691	4,117
Golf	Holes	513	198	711	1,293	852	2,145
Outdoor Games	Acres	742	944	1,686	3,740	5,159	8,899
Combined Trail Activity	Miles	58	44	102	392	246	638
Horseback Riding	Miles	41	29	70	138	583	721
Watersports	Surface Acres	65,400	88,614	154,014	21,909	33,314	55,233

Source: Data compiled by SCS from Oklahoma's "Statewide Comprehensive Outdoor Recreation Plan (SCORP) and Texas Outdoor Recreation Plan (TORP).

Generally, sufficient water to meet present needs is available from surface or ground sources in the study area. The amount of freshwater available decreases from east to west, corresponding with decreasing average annual rainfall.

Surface Water

Streamflow Quantity: The runoff or streamflow in the basin varies primarily with precipitation. The average annual precipitation ranges from 16 to 39 inches from west to east respectively, and the average annual runoff ranges from one to seven inches from west to east respectively. Other factors which affect the runoff are soil infiltration rate, cover conditions, intensity of rainfall, soil moisture condition, underground recharge, and undrained basins. Runoff records are available for various gaging stations within the basin. A list of current and historical gaging stations maintained under various funds can be found in "Water Resources Investigations of the U. S. Geological Survey", with the following data included: water quality parameters, station purpose, network classification, source of current stage, source of funds and station type. The average annual discharges for selected gaging stations are given in Table 4-10. However, some of the gages will not reflect the total yield of a watershed because some of the water is utilized within that watershed for municipal, irrigation or industrial use. It is estimated that only 30 percent of the water used for irrigation and 50 percent of the water used by municipalities is returned to underground recharge or streamflow.

The Durwood gage located at the lower end of the Washita basin recorded a discharge of 1,431,000 acre-feet for the water year of 1974 and shows an annual average discharge of 999,100 acre-feet for 46 years of record. This represents 2.60 inches of runoff for the drainage area above Durwood.

The Gainesville gage located on the Red River immediately above Lake Texoma recorded a discharge of 1,680,000 acre-feet for the water year of 1974 and shows an annual average discharge of 1,975,000 acre-feet for 38 years of record. This represents 1.20 inches of runoff from the drainage area above Gainesville.

There is some intervening drainage area contiguous to Lake Texoma unaccounted for by either the Durwood or Gainesville gages.

TABLE 4-10

Stream Flow Gaging Stations

Red River Basin Above Denison Dam

Gage No.	Gage Name	Drainage Area Sq.Mi.	Years of Record Yrs.	Discharge 8/ Maximum CFS	Minimum CFS	Average Ac.Ft./Yr	Inches
07298200	Tule Creek, Silverton Texas	1,150	9	9,990	0	6,690 9/	0.11
07299200	Prairie Dog Town Fork near Lakeview, Texas	6,792	11	51,000	0	53,250	0.15
07299300	Little Red River near Turkey, Texas	139	6	3,570	0	8,040	1.09
07299570	Red River near Quanah, Texas	8,321	14	64,000	0	102,900	0.24
07300000	Salt Fork Red River near Wellington, Texas 10/	1,222	15	146,000	0.1	49,920	0.76
07300500	Salt Fork Red River at Mangum, Oklahoma	1,566	37	72,000	0	63,180	0.76
07301500	North Fork Red River near Carter, Oklahoma	2,337	28	53,400	0	84,770	0.68
07303500	Elm Fork Red River near Mangum, Oklahoma	838	21	30,600	0	72,230	1.62
07304500	Elk Creek near Hobart, Oklahoma	549	28	22,400	0	49,270	1.68
07305000	North Fork Red River near Headrick, Oklahoma 4/	4,244	39	30,700	0	216,600	0.96
07307800	Pease River near Childress, Texas	2,754	9	19,000	0	49,120	0.34
07311000	East Cache Creek near Walters, Oklahoma	675	30	28,200	0	121,700	3.38
07311500	Deep Red Run near Randlett, Oklahoma	617	25	48,700	0	80,420	2.44
07311900	Wichita River near Seymour, Texas	1,874	14	23,100	0	126,100	1.26
07313500	Beaver Creek near Waurika, Oklahoma	563	21	32,200	0	73,900	2.46
07315500	Red River near Terral, Oklahoma 4/	28,723	36	197,000	43	1,576,000	1.03
07315900	Walnut Bayou near Burneyville, Oklahoma	314	6	3,860	0	28,110	1.68
07315700	Mud Creek near Courtney, Oklahoma	572	14	33,400	0	77,520	2.54
07316000	Red River near Gainesville, Texas 4/	30,782	39	168,000	48	1,975,000	1.20
07316500	Washita River near Cheyenne, Oklahoma	794	37	69,800	0	22,240	0.53
07325000	Washita River near Clinton, Oklahoma	1,977	25	66,800	0	105,700	1.00
			14 2/	-	-	32,310	0.31
07325500	Washita River at Carnegie, Oklahoma 1/	3,129	37	50,000	0	200,000	1.20
07326000	Cobb Creek near Port Cobb, Oklahoma	313	19	35,000	0.2	36,340	2.18
			16 3/	-	-	10,360	0.62
07326500	Washita River at Anadarko, Oklahoma 2/ 3/	3,656	19	29,000	0	278,200	1.43
07327000	Sugar Creek near Gracemont, Oklahoma 7/	208	19	8,500	0	10,650	0.96
07327490	Little Washita River near Minnekah, Oklahoma 7/	208	11	7,560	0	17,240	1.55
07328100	Washita River near Alex, Oklahoma 2/ 3/ 7/	4,787	10	9,350	0	236,200	0.92
07328500	Washita River near Pauls Valley, Oklahoma 2/ 3/	5,330	37	35,800	0	501,400	1.76
07329500	Rush Creek near Maysville, Oklahoma 7/	206	20	38,500	0	36,590	3.32
07331000	Washita River near Durwood 2/ 3/ 6/	7,202	46	98,000	0	999,100	2.60
07331600	Red River at Denison Dam near Denison, Texas 4/ 5/	39,720	51	201,000	12	3,446,000	1.63

1/ Flows regulated due to Altus Dam.
2/ Flows regulated due to Foss Reservoir.
3/ Flows regulated due to Fort Cobb Reservoir.
4/ Flows regulated due to dams above gage.
5/ Flows regulated due to Denison Dam.
6/ Flows regulated due to Arbuckle Reservoir.
7/ Flows regulated due to SCS floodwater retarding structures.
8/ Water Resource Data - Water Year 1974 - USGS.
9/ Prior to completion of MacKenzie Dam.
10/ Flows regulated due to Greenbelt Reservoir.

Source: U. S. Geological Survey Water - Data Report.

The Denison gage located on the Red River below the Texoma dam site shows a discharge from the entire basin of 3,734,000 acre-feet for the water year of 1974 and an annual average discharge of 3,446,000 acre-feet for 51 years of record. This represents 1.63 inches of runoff from the Red River Basin drainage area above Denison Dam.

The average annual discharge recorded by the Denison gage for the past 20 years has been 3,110,000 acre-feet and for the last 10 of those years the average annual discharge has been 3,211,000 acre-feet.

The Texas Water Rights Commission issues surface water permits in Texas. The Texas Water Rights Adjudication Act of 1967 authorizes the Texas Water Rights Commission to investigate and recommend, with the Court's approval, the nature and measure of water rights for all authorized diversions from surface water streams or portions thereof except domestic and livestock uses and to monitor and administer each water right. It is estimated that the 11 major streams in the Oklahoma portion of the basin, excluding the Red River mainstream, have a combined average yield of 2,081,000 acre-feet per year.

The Oklahoma Water Resources Board has issued surface water permits in the Oklahoma portion of the basin for the use of 599,000 acre-feet per year. The remaining 1,482,000 acre-feet are unallocated. A large portion of the 599,000 acre-feet of surface water permits apply to major, minor, PL-534, and PL-566 reservoirs that contain multiple purpose storage. The remaining permits are for water use directly from stream flow, Table 4-11.

A survey of the quality gaging stations in Oklahoma reveals 1,011,000 acre-feet per year of runoff for which no use permits have been issued and which is of suitable quality for irrigation or industrial use. Of this amount 270,000 acre-feet is suitable for municipal use. This 270,000 acre-feet is located in the Cache and Mud creek basins. The remaining 741,000 acre-feet of unallocated water suitable for irrigation and industry is located in the lower one-third of the Washita basin.

The remaining unallocated annual flow outside of the Washita River, Mud, and Cache Creek basins is 471,000 acre-feet which is generally of poor quality and not suitable for municipal, industrial, or irrigation use. However, some areas such as small towns or irrigation systems have some good water for local uses.

TABLE 4-11

Surface Water Permits

Red River Basin Above Denison Dam

Oklahoma

Name of Stream System	Drainage Area of Stream System Sq. Mi.	Number of Permits 1/	Stream Water: Average Yield 1,000 Ac/Ft/Yr	Stream Water: Allocated 1,000 Ac/Ft/Yr	Stream Water: Not Allocated 1,000 Ac/Ft/Yr	Useable Water 1,000 Ac/Ft/Yr: Mun.	Useable Water 1,000 Ac/Ft/Yr: Ind.	Useable Water 1,000 Ac/Ft/Yr: Irr.
Washita River	7,490	987	1,039	298	741	-	741	741
Mainstem (Washita to Walnut Bayou)	653	22	191 2/	6	185	-	-	-
Walnut Bayou	336	2	30	3	27	-	-	-
Mud Creek	958	24	130	10	120	-	-	-
Beaver Creek	857	80	84 5/	62	22	22	22	22
Cache Creek	2,069	155	324	76	248	248	248	248
Mainstem (Cache to North Fork)	385	8	51 3/	1	50	-	-	-
North Fork of Red River	2,194	170	128 6/	123	5	-	-	-
Salt Fork of Red River	700	87	28	14	14	-	-	-
Lebos and Gypsum	498	28	20 4/	4	16	-	-	-
Elm Fork	647	12	56	2	54	-	-	-
Total	16,787	1,575	2,081	599	1,482	270	1,011	1,011

1/ Number of permits as of September 30, 1976
2/ Using average runoff 5.5"
3/ Using average runoff 2.5"
4 Estimated, using Salt Fork at Mangum average
5/ With Waurika Reservoir in place
6/ 34,800 Ac/Ft/Yr added for diversion from Lake Altus
7/ Streams are only for Oklahoma portion

Source: SCS, Oklahoma Water Resources Board

Current Surface Water Development: Reservoirs in the basin, other than farm ponds, have been classified according to size as major, minor, and those authorized for construction by PL-534 and PL-566.

There are 20 major reservoirs within the basin, Table 4-12, which supply water for purposes such as fish and wildlife, irrigation, municipal, navigation, power, recreation, regulation flows, and water quality. Lake Texoma located at the lower end of the basin controls all water from the basin and reservoirs above Texoma control varying amounts within the basin.

The combined conservation and sediment storage of these twenty reservoirs is 4,616,330 acre-feet. The surface area of the conservation pools is 190,865 acres.

There are 274 minor reservoirs within the basin, Table 4-13, used for small water supplies, club lakes, fishing, and farm purposes. These lakes have a total conservation storage of 307,038 acre-feet and a surface area of 20,817 acres.

Within the basin there are 1,328 floodwater retarding structures authorized for construction in Oklahoma and 93 in Texas by PL-534 and PL-566, Tables 4-14 and 4-15. These structures have 309,392 acre-feet of floodwater storage. The conservation storage consists of 660 acre-feet of irrigation, 80,966 acre-feet municipal, 10,932 acre-feet recreation, 711 acre-feet fish and wildlife, and the remainder is for sediment accumulation. It is estimated that the structures planned in Oklahoma for municipal storage will yield 11,600 acre-feet per year and those with irrigation storage will yield 450 acre-feet per year. These structures will control the runoff from 4,010 square miles of drainage area.

Table 4-16 summarizes major, minor, and SCS flood control structures. There are 1,740 of these reservoirs in the basin. Lake Texoma is included in this number and its storage and surface area is common to both Texas and Oklahoma. The surface area of the conservation pools is 251,927 acres. They contain 5,269,196 acre-feet of conservation storage, 4,902,359 acre-feet of flood storage for a combined total storage of 10,171,555 acre-feet.

Stream Water Quality: Streamflow quality in the basin is affected by natural sources and/or manmade sources. Generally speaking, the quality of surface water is related to natural conditions in its normal contact with geological

TABLE 4-12

Inventory of Major Reservoirs

Red River Basin Above Denison Dam

	Drainage Area 1/ Sq. Mi.	Purpose 2/	Conservation Pool Surface Acre	Conservation Pool Ac. Ft. 4/	Flood Storage Ac. Ft.	Water Supply Yield 6/ Ac. Ft./Yr.
Altus Dam and Reservoir	2,560	F, I, M & R	6,260	134,549	19,596	16,800 7/
Arbuckle Reservoir	126	F, FW, M & R	2,350	72,490	36,440	22,700
Denison Dam-Lake Texoma	39,719	F, M, N, R, P & RF	89,000	2,722,000	2,660,000 5/	2,977,000 8/
Fort Cobb Dam and Reservoir	315	F, FW, I & M	4,098	79,300	63,300	13,300 9/
Foss Dam and Reservoir	1,450	F, I, M & FW	8,800	256,090	379,780	18,000 10/
Lake Ellsworth	246	M & R	6,000	93,000	-	9,500
Lake Lawtonka	96	M & R	3,300	64,000	-	8,500
Mountain Park Dam and Reservoir	681	F, FW, M & R	6,378	96,181	19,535	16,000 11/
Waurika Lake 3/	562	F, FW, WQ I, M & R	10,600	202,900	266,400	46,500
Subtotal Oklahoma (9 structures)			136,786	3,720,500	3,445,051	3,128,300
Buffalo	2,075	FW, R	1,900	18,150 1/	-	-
Greenbelt	547	M, IO, M	2,025	60,400	21,360	-
Santa Rosa Lake	336	Private Ownership	1,500	11,570 1/	-	-
Kemp	2,086	F, M, I	16,540	319,600	248,300	-
Diversion	-	F, M, I	3,419	40,000	-	-
N. Fork Buffalo Creek	33	F, M, I	1,500	15,400	-	-
Lake Wichita	143	M, IO	2,200	14,000	-	-
Kickapoo	275	M, ID	6,200	106,000	-	-
Lake Arrowhead	832	F, M, ID	16,200	262,100	289,300	-
Lake Nocona	94	M, ID, MI	1,470	25,400	-	-
Moss Reservoir	65	M, IO	1,125	23,210	-	-
Subtotal Texas (11 structures)			54,079	895,830	558,960	
Basin Total			190,865	4,616,330	3,687,260	

1/ Total
2/ F-Flood Control, FW-Fish and Wildlife, I-Irrigation, M-Municipal Water Supply, N-Navigation, P-Power, R-Recreation, RF-Regulating Flows, WQ-Water Quality, ID-Industrial, and MI-Mining.
3/ Under Construction
4/ Includes Sediment Storage
5/ Includes 38,850 acre-feet for water supply
6/ Phase I, Oklahoma Comprehensive Water Plan
7/ 4,800 M and 12,000 I
8/ 23,700 M and 2,953,300 P
9/ 9,000 M and 4,300 I
10/ 11,300 M and 6,200 I
11/ 46,500 M and 5,000 I

Source: Oklahoma Water Resources Board, Texas Water Development Board.

TABLE 4-13

Inventory of Minor Reservoirs 1/

Red River Basin Above Denison Dam

Sub-Basin	Club, Fishing and Farm Purpose Lakes 2/			Small Water Supply Lakes			Total		
	Number	Area	Storage	Number	Area	Storage	Number	Area	Storage
Washita Basin	145	2,090	13,292	11	2,951	37,077	156	5,041	50,369
Outside Washita Basin	106	8,698	182,208	6	1,174	13,675	112	9,872	195,883
Subtotal (Oklahoma)	251	10,788	195,500	17	4,125	50,752	268	14,913	246,252
Subtotal (Texas)	23	3,922	40,756	8	1,982	20,030	31	5,904	60,786
Basin Total	274	14,710	236,256	25	6,107	70,782	299	20,817	307,038

1/ Includes reservoirs larger than 10 surface acres built by entities other than SCS, Corps of Engineers or Bureau of Reclamation

2/ Includes Lake Murray that has 5,728 surface acres and 153,250 acre-feet of conservation storage.

Source: SCS, Oklahoma Water Resources Board, Texas Water Development Board

Inventory of Washita (PL-534) and (PL-566) Watershed Reservoirs Authorized

Red River Basin Above Denison Dam
(Oklahoma) 1/

Sub-Basin	No. of Sites	Drainage Area Controlled Sq.Mi.	Sediment 50 Years Acre Feet	Sediment 50 Years Sur. Acre	Sediment 100 Years Acre Feet	Sediment 100 Years Sur. Acre	Sediment Reserve Acre Feet	Sediment Total Acre Feet	Recreation Pool Acre Feet	Recreation Pool Sur. Acre	Irrigation Pool Acre Feet	Irrigation Pool Sur. Acre	Municipal Pool Acre Feet	Municipal Pool Sur. Acre	Other Pool Acre Feet	Other Pool Sur. Acre	Top of Riser Acre Feet	Top of Riser Sur. Acre	Detention Pool Acre Feet	Detention Pool Sur. Acre	Total Storage Acre Feet
BUILT																					
Washita Basin (PL-534)	967	2573.60	143,889	21,956	3,465	1,187	18,211	165,565	6,127	1,433	258	184	71,166	5,882	711	135	224,260	26,174	534,982	66,822	778,309
PL-566	84	365.05	11,149	2,053	4,176	825	2,766	18,091	2,474	636	402	195	8,300	925	-	-	24,959	3,286	64,519	8,849	93,786
Subtotal	1,051	2938.65	155,038	24,009	7,641	2,012	20,977	183,656	8,601	2,069	660	379	79,466	6,807	711	135	249,219	29,460	599,501	75,671	872,595
AUTHORIZED BUT NOT BUILT																					
Washita Basin (PL-534)	156	542.49	20,574	3,609	111	41	4,553	25,238	-	-	-	-	-	-	-	-	20,633	3,680	110,046	12,787	135,284
PL-566	121	528.39	17,840	3,887	5,236	507	4,434	27,510	2,331	528	-	-	1,500	370	-	-	23,385	4,522	105,051	14,866	136,392
Subtotal	277	1070.88	38,414	7,496	5,347	548	8,987	52,748	2,331	528	-	-	1,500	370	-	-	44,018	8,202	215,097	27,653	271,676
TOTAL AUTHORIZED																					
Washita Basin (PL-534)	1,123	3116.09	164,463	25,565	3,576	1,228	22,764	190,803	6,127	1,433	258	184	71,166	5,882	711	135	244,893	29,854	645,028	79,609	914,093
PL-566	205	893.44	28,989	5,940	9,412	1,332	7,200	45,601	4,805	1,164	402	195	9,800	1,295	-	-	48,344	7,808	169,570	23,715	230,178
TOTAL	1,328	4009.53	193,452	31,505	12,988	2,560	29,964	236,404	10,932	2,597	660	379	80,966	7,177	711	135	293,237	37,662	814,598	103,324	1,144,271

1/ December 1974

Source: SCS

TABLE 4-15

Inventory of Washita (PL-534) and (PL-566) Watershed Reservoirs Authorized

Red River Basin Above Denison Dam

(Texas) 1/

Sub-Basin	No. of Sites	Drainage Acre Controlled Sq.Mi.	Sediment 2/ 50 Years Acre Feet	Sediment 2/ 50 Years Sur. Acre	Sediment 2/ 100 Years Acre Feet	Sediment 2/ 100 Years Sur. Acre	Sediment 2/ Reserve Acre Feet	Sediment 2/ Total Acre Feet	Recreation Pool Acre Feet	Recreation Pool Sur. Acre	Irrigation Pool Acre Feet	Irrigation Pool Sur. Acre	Municipal Pool Acre Feet	Municipal Pool Sur. Acre	Other Pool Acre Feet	Other Pool Sur. Acre	Top of Riser Acre Feet	Top of Riser Sur. Acre	Detention Pool Acre Feet	Detention Pool Sur. Acre	Total Storage Acre Feet
BUILT																					
Washita Basin (PL-534)	38	302.84	7,901	1,377	-	-	1,867	-	-	-	-	-	-	-	-	-	7,911	1,332	42,362	5,163	52,140
PL-566	22	98.76	4,113	601	-	-	2,980	-	-	-	-	-	-	-	-	-	4,118	601	16,191	1,921	23,289
Subtotal	60	401.60	12,019	1,978	-	-	4,847	-	-	-	-	-	-	-	-	-	12,029	1,933	58,553	7,084	75,429
AUTHORIZED BUT NOT BUILT																					
Washita Basin (PL-534)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25,197	-	-
PL-566	33	229.54	4,126	633	-	-	2,365	-	-	-	-	-	-	-	-	-	4,126	633	-	3,295	31,688
Subtotal	33	229.54	4,126	633	-	-	2,365	-	-	-	-	-	-	-	-	-	4,126	633	25,197	3,295	31,688
TOTAL AUTHORIZED																					
Washita Basin (PL-534)	38	302.84	7,901	1,377	-	-	1,867	-	-	-	-	-	-	-	-	-	7,911	1,332	42,362	5,163	52,140
PL-566	55	198.76	8,244	1,234	-	-	5,345	-	-	-	-	-	-	-	-	-	8,244	1,234	41,388	5,216	54,977
TOTAL	93	501.60	16,145	2,611	-	-	7,212	-	-	-	-	-	-	-	-	-	16,155	2,611	83,750	10,379	107,117

1/ September 30, 1976

2/ Risers are ported to 200 acre-feet elevation

Source: SCS

TABLE 4-16

Inventory Summary of Surface Reservoirs

Red River Basin Above Denison

Type	Number	Conservation Storage 2/ Surface Acre	Conservation Storage 2/ Ac. Ft.	Flood Storage Ac. Ft.	Total Storage Ac. Ft.
SCS Watershed Structures 1/	1,328	37,662	329,673	814,598	1,144,271
Minor Reservoirs 3/ 3/	268	14,913	246.252	4/	246.252
Major Reservoirs 5/	9	136.758	3,720,500	3,445,051	7,165,551
Subtotal (Oklahoma)	1,605	189,333	4,296,425	4,259,649	8,556,074
SCS Watershed Structures 1/	93	2,611	16,155	83,750	99,905
Minor Reservoirs 3/	31	5.904	60,786	4/	60,786
Major Reservoirs 5/	11	54,079	895,830	558,960	1,454,790
Subtotal (Texas)	135	62,594	972,771	642,710	1,615,481
Basin Total	1,740	251,927	5,269,196	4,902,359	10,171,555

1/ Storage for all purposes authorized for construction by SCS.
2/ Includes sediment storage
3/ Includes reservoirs larger than 10 surface acres built by entities other than SCS, Corps of Engineers or Bureau of Reclamation.
4/ Flood storage usually minor.
5/ Storage reservoirs built or authorized for construction by Corps of Engineers and Bureau of Reclamation with Lake Ellsworth and Lake Lawtonka built by municipalities included in this group.

Source: SCS, TWDB and Oklahoma Water Resources Board.

formations. Therefore, the quality varies considerably throughout the basin. Manmade pollution caused by municipal effluent, industrial wastes, feed lot drainage, and other agricultural related activities are being scrutinized by the Environmental Protection Agency and recommendations for improvement are being formulated.

Intensive pollution data on parameters such as chemical oxygen demand and suspended solids plus more related pollution data, can be found in "Water Quality Management Plan - Upper Red River Basin" State of Oklahoma, Department of Pollution Control or "State Water Quality Management", Texas Water Quality Board.

Quality varies within river systems. The Washita River system, for example, makes up 44 percent of the Oklahoma portion of the basin and lies generally within the Red Beds. Its stream water quality varies considerably from the Texas-Oklahoma state line to Lake Texoma.

Abrupt changes in the geology adjacent to the Washita River as it enters Oklahoma from Texas brings about a corresponding abrupt change in the mineral quality of the stream. Westward from the State line water quality is very good, being characteristic of a water derived from the High Plains deposit of the Texas Panhandle. The river, at this point, has a dissolved solids content of less than 400 ppm, a hardness of 200 ppm, and no appreciable sulfate. The mineral content of the stream increases almost immediately east of the State line as the river flows through exposed beds of gypsum deposits, associated with the Red Beds. From the State line to Cheyenne, the mineral content and hardness increases about threefold, and in general concentrations become progressively higher downstream as far as Foss and Clinton. A maximum hardness of 2,000 ppm has been observed during low flow periods at Clinton.

From Clinton downstream to Lake Texoma, water quality improves gradually as a result of tributary inflow. This pattern is shown by the average annual figures for periods 1954 - 1967 at Carnegie station and 1951 - 1966 records at Durwood station. The average concentrations between Carnegie and Durwood decreased from 826 ppm of dissolved solids and 510 ppm of hardness at Carnegie to 509 ppm dissolved solids and 317 ppm of hardness at Durwood.

Several tributary streams in the lower Washita River basin are subject to momentary salt concentrations as a result of oil field activities. These include Little Washita River

Rush Creek, Wildhorse Creek, and Caddo Creek. For example, at times chloride concentrations of Rush Creek near Maysville exceeds 1,700 ppm although the minimum is only 12 ppm. The high concentration normally occurred on low flow days and did not influence greatly the overall Washita River quality. The average chloride concentration at downstream Durwood station for the water year 1974 was 41 ppm.

As mentioned previously, a number of small tributary streams at the lower end of the Washita such as Oil Creek, Mill Creek, and Pennington Creek cause a marked improvement in the quality of water coming from the Red River.

For example, the monthly average chloride concentrations decreased from 802 ppm at Gainesville station to 341 ppm for water released from the dam during the two-year period of 1973 and 1974.

Table 4-17 reveals the quality of stream flows for selected years at active gaging stations.

Red River water upstream from Lake Texoma is of poor quality due to the combination of oil field brines, natural salt, and gypsum deposits. Most of the natural salt and gypsum contributions come from the upper reaches of the stream system, from such sources as Lebos Creek, Gypsum Creek, Turkey Creek, Prairie Dog Town Fork, and Elm Fork.

The existing water quality within Beaver Creek and its tributaries is quite variable. During periods of low flow the stream water is characterized by moderate to large chloride concentrations. Blue Beaver Creek drains the granites of the Wichita Mountains which results in runoff of very good quality. For similar reasons, the stream quality of the upper reaches of West Cache Creek and Deep Red Run are also low in dissolved solids and, therefore, of good quality.

Water of poor quality occurs in Deep Red Run near Randlett due to the high chloride content. The water is not suitable for municipal usage during periods of low flow.

There are two major impoundments in Cache Creek basin, Lake Lawtonka, and Lake Ellsworth. Both have been placed near the top of the Cache Creek Watershed, and impound the waters of Medicine and East Cache Creeks, respectively.

With few exceptions, the water quality in the Oklahoma portion of the North Fork to the Red River drainage area is generally too high in mineral concentrates for use as municipal water.

TABLE 4-17

Average of Annual Weighted Average Quality Values for Streams in Basin

(Results in parts per million except as indicated)

Red River Above Denison Dam

Station	Water Year	Sulfate (SO_4)	Chloride (Cl)	Dissolved Solids (residue at 180° C)	Hardness as $CaCO_3$	Sodium Absorption Ratio (SAR)	Specific Conductance (Micromhos at 25° C)	Mean Discharge (cfs)
No. 07300000-Salt Fork Red River near Wellington, Texas 3/	1952-74	1,300	270	2,400	1,500	2.2	2,900	21
No. 07301500-North Fork Red River near Carter	1961 1/	471	182	1,220	-	-	1,640	312
	1974	359	163	966	129	2.3	1,410	47 2/
No. 07303500-Elm Fork Red River near Mangum	1974	762	901	2,872	98	6.1	4,361	41 2/
No. 07304500-Elk Creek near Hobart	1950-51							
	1959-63 1/	177	43	523	312	1.1	738	96
	1974	130	45	518	177	1.0	790	56 2/
No. 07305000-North Fork Red River near Headrick	1960-63 1/	596	755	2,320	755	7.2	3,450	384 2/
	1974	184	419	1,340	82	4.0	2,079	222 2/
No. 07308500-Red River near Burkburnett, Texas	1960-74	770	1,200	3,200	970	14.0	5,120	723
No. 07311000-East Cache Creek near Walters	1952-53 1/	29	30	242	132	1.2	402	89
	1974	20	22	199	104	1.1	316	89 2/
No. 07316000-Red River near Gainesville, Texas 3/	1936-74	370	800	2,000	610	12.0	3,300	1,379
No. 0732550-Washita River at Carnegie	1957-67 1/	400	47	826	510	0.8	1,080	272
	1974	460	52	978	168	0.9	1,269	235 2/
No. 0733100-Washita River near Durwood	1951-66 1/	243	48	509	317	0.9	745	1,052
	1974	88	41	392	158	0.9	611	1,976

Source: 1/ Oklahoma Water Resource Region Reports
2/ Water Resources Data for Oklahoma - Part 1
3/ U. S. Geological Survey Water-Data Report Texas 76-1

The water of Elk Creek and Otter Creek is of better quality than the water of the rest of the segment.

Above its confluence with the Elm Fork, the North Fork is suitable for municipal uses when impounded. Impounding allows for mixing of high and low flows to occur, averaging the stream quality of the North Fork. This is currently being done within the Altus-Lugert Reservoir on the main stem of the North Fork. Although the reservoir contains large amounts of sulfate, Lake Altus is providing municipal water to Altus and irrigation water to the Lugert-Altus Irrigation Project.

The highest concentration of dissolved solids and chlorides in the basin occurred in Elm Fork of the North Fork Red River near Carl. Values for dissolved solids and chloride concentrations were 62,900 and 34,000 ppm respectively. The high chloride content of the water is due to salt water springs and seeps above the Carl monitoring stations. The effects of the salty flow of the Elm Fork on the North Fork Red River is indicated by the high chloride concentrations (maximum of 5,090 ppm) at the Headrick station. The chloride concentrations at Headrick exceed 250 ppm ninety-nine percent of the time.

The U. S. Army Corps of Engineers is developing plans to contain these springs.

The quality of the water of the Salt Fork Red River and the North Fork Red River above Altus-Lugert Reservoir is somewhat similar. Water of both streams are of the calcium sulfate type. The sulfate content of the Salt Fork is greater than that of the North Fork.

The water in the lower reaches of Gypsum, Lebos, and Turkey creeks is more mineralized than the water of the Salt Fork Red River. The higher mineral content of these streams is due primarily to the high chloride content.

At present there are no impoundments in the Salt Fork basin. The towns and communities meet their water needs with ground water.

From the confluence of the Wichita River and Red River to Lake Kemp, the average chloride level is 1,800 ppm. The sulfate and total dissolved solids average 800 ppm and 5,000 ppm, respectively.

The tributaries of Lake Kemp consisting of the North, Middle, and South Forks of the Wichita River have an average of

1,100 ppm chloride, 730 ppm sulfate, and 2,900 ppm dissolved solids.

Additional data on quality can be obtained from Oklahoma Water Resources Board Publication, "Appraisal of the Water and Related Land Resources of Oklahoma", or the Texas Water Quality Board, "State Water Quality Management - FY 1975".

Ground Water

The total estimated ground water storage in the Oklahoma portion of the basin is 51,740,000 acre-feet of which only 18,829,000 acre-fee are estimated to be available due to cost and physical problems of developing the water use. The Texas portion shows 76,000,000 acre-feet with 37,000,000 acre-feet available, Table 4-18. Ground water yields are shown on Plate 4-12. Most of these waters are suitable for irrigation except for local areas where high concentrations of various minerals are present. The Paluxy and Woodbine formations and Dog Creek Shale and Gypsum are of poor quality and not suited for municipal use. A portion of the other waters would not be suitable for municipal use, such as areas in the Simpson Group which have high sulphur content. The Alluvium and Terrace deposits vary throughout the basin; therefore, municipal use is questionable in many areas of these deposits. The water quality varies by formation or group. In fourteen wells studied in the Rush Springs Sandstone the dissolved solids range from 220 to 1,355 parts per million (ppm); sodium 6 to 63 ppm; and chloride 7 to 212 ppm.

The aquifers of most significance in this portion of the study area are the remnants of alluvial sediments of Quaternary age. The alluvial patches lie on Triassic and Permian rocks and are generally small in area. A significant large deposit is found in Collingsworth County, and considerable pumpage from the aquifer is used by the City of Wellington and by farmers for irrigation.

The overall water quality within the Alluvim and Terrace deposits of the Washita and the Red Rivers is good. The water quality in the Terrace deposits is higher than that of the Alluvium because it is less affected by influent seepage of highly mineralized river water. The dissolved solids range from 477 to 1,050 ppm.

The most important ground water reservoir within the study area is the Ogallala Formation of the high plains. The water ranges from 25 to 300 feet below the land surface. The saturated thickness ranges from less than 50 feet in many places to more than 300 feet. The zone of saturation is generally thicker in the northern part of the high plains than the southern part. The volume of water in storage in the Ogallala as of 1958 was estimated at 63,000,000 acre-feet, with an estimated annual yield of 250,000

TABLE 4-18

Ground Water Data

Red River Basin Above Denison Dam

Ground Water Aquifer	Water in Storage Acre/Feet	Estimated Percent Recoverable	Estimated Total Available Water Acre/Feet	Average Thickness of Formation Feet	Average Yield (Gallons per Minute)	Dissolved Solids (PPM)
Alluvium and Terrace Deposits	5,520,000	62	3,422,400	40-60	100-500	477-1050
Ogallala Formation	200,000	62	124,000	300-400	500	200-500
Antlers Sand	1,500,000	50	750,000	400-880	20-1700	500-1000
Elk City Sandstone	1,400,000	45	630,000	185	200	-
Rush Springs Sandstone	31,200,000	53	16,536,000	250-300	400	179-2270
Dog Creek Shale & Blaine Gypsum	530,000	60	318,000	150-300	10-2000	-
Oscar Formation	8,900,000	40	3,560,000	100	200	-
Simpson Group	990,000	53	524,700	2500-3000	200-600	-
Arbuckle Group	1,500,000	62	930,000	2500-3000	200-600	-
Subtotal (Oklahoma)	51,740,000		26,795,100			
Alluvium and Terrace Deposits	8,000,000	50	4,000,000	75	300	300-1500
Ogallala Formation	63,000,000	50	31,500,000	500	500	300
Woodbine Formation	5,000,000	30	1,500,000	500	175	100-1000
Blaine Gypsum	NA 1/	NA 1/	NA 1/	175	400	2000-5000
Subtotal (Texas)	76,000,000		37,000,000			
Basin Total	127,740,000		63,795,100			

1/ NA - Not Available

Source: SCS

acre-feet. The recharge to the formation is small compared to the amount being withdrawn, and consequently, the water level in wells has steadily declined since irrigation began in 1937. Total declines now range from 20 to 120 feet.

The water obtained from the Ogallala is typically hard and has an objectionably high concentration of fluoride in many areas. The hardness, in addition to a high concentration of silica, makes it somewhat objectional for domestic and many industrial uses. Dissolved solids range from 300 to 800 parts per million. Except where locally contaminated by seepage from lime pits, the water is satisfactory for irrigation. Only the excessive fluoride content makes it objectionable for public supply.

The Woodbine Aquifer occurs in eastern Cooke and Grayson counties. It consists of medium-to coarse-grained, cross-bedded, unconsolidated sand, and laminated shaly clay interbedded with layers of lignite and gypsiferous clay. Many of the sands are highly lenticular and grade laterally into the clay within short distances, with the thicker and more massive sand beds being near the base of the formation. Thickness of the aquifer ranges from about 400 feet near the outcrop to about 600 feet. Artesian conditions exist in the aquifer downdip from the outcrop. Yields from the large capacity wells average about 175 gallons per minute (gpm), with some reaching 700. Water quality is good.

The Trinity Group Aquifer is represented within the study area by the Antlers Sand and is present in eastern Montague and western Cooke, Marshall, Love, and a small part of Carter counties. The aquifer consists of a basal conglomerate and gravel, overlain by fine to coarse grained, poorly consolidated, massive, cross-bedded sand, interbedded with purple, red, and gray clay. Thickness of the aquifer ranges from about 400 feet near the outcrop in Cooke County to about 1,000 feet in the downdip area. Yields of large capacity wells in the Trinity Group Aquifer average about 325 gallons per minute, and some reach 700. Approximately 3,700 acre-feet of water is available annually from the Trinity Group Aquifer in the basin. In general, the water contains less than 1,000 ppm dissolved solids, and is suitable for municipal and most industrial uses. The contents of dissolved solids progressively increases toward the southeast.

The Elk City Sandstone members of the Quartermaster Formation occur in western Washita and eastern Beckham counties. It is similar to the Rush Springs Sandstone in that it is a fine grained sandstone with little or no shale content. However, it differs from the Rush Springs Aquifer in being of much smaller areal extent and considerably thinner. The water quality is generally suitable for all uses. The aquifer is presently providing water to the towns of Clinton, Cordell, Canute, and Dill City.

LEGEND

GROUND WATER YIELD
(IN GALLONS PER MINUTE)

- 0 TO 50
- 50 TO 500
- 50 TO 500 (AREAS OF SCANTY INFORMATION)
- 500 TO 1000
- MORE THAN 1000

SOURCE: U. S. Geological Survey and the Texas Water Development Board.

PLATE 4-12

GROUND WATER

RED RIVER BASIN ABOVE DENISON DAM

NEW MEXICO, TEXAS AND OKLAHOMA

APPROXIMATE SCALE - MILES

Base compiled from USGS Quad Sheets.
Lambert Conformal Conic Projection

OCTOBER 1976 4-R-35769

APRIL 1974 4-R-32846

USDA-SCS-FORT WORTH TEXAS 1977

The Rush Springs Sandstone is a fine grained, cross-bedded sandstone, containing irregular silty lenses. Yields from this aquifer average about 400 gallons per minute. The water is usually suitable for all general uses. The median concentrations for dissolved solids and hardness are 296 and 179 ppm respectively. Depth to water below land surface ranges from 0 - 150 feet. The Rush Springs Sandstone is an extensive aquifer, outcropping over an area of about 1,900 square miles in Caddo, Custer, Washita, and small parts of Comanche, Dewey, and Grady counties.

The Blaine Gypsum Formation is a secondary aquifer in parts of Collingsworth and Childress counties. The aquifer contains water-soluble rocks and is locally very permeable, so that high yields are obtained in some locations. Yields may range from near nothing to 1,650 gpm. The quality of the water is very poor because of a high sulfate content and, at times, a high chloride content. The water is not suitable for public use and its continued use for irrigation requires special field conditions and management. Approximately 40,000 acre-feet of water is available annually from the Blaine Aquifer.

The Dog Creek Shale and Blaine Gypsum aquifers occur in Harmon and parts of Jackson, Greer, and Beckham counties in the Oklahoma portion of the basin.

The Oscar Formation consists of interbedded shale, sandstone, and limestone conglomerate. The aquifer occurs in western Stephens, southwestern Garvin, southwestern Carter, and eastern Jefferson counties. The wells commonly yield water of suitable quality for most uses at an average rate of between 150 and 180 gallons per minute. Ardmore, Healdton, Ringling, and Duncan are presently using or have used wells in the Oscar Formation for municipal supplies.

The Simpson Group of Middle Mississippian to Upper Ordivician Age consists of fine grained, loosely cemented and friable sandstones. The aquifer outcrops in southwestern Murray and northeastern Carter counties. Water from the sandstones is of poor quality at Sulphur, but elsewhere it is usually potable.

The Arbuckle Group Aquifer provides water to wells in the vicinity of Lawton, Cache, and Indiahoma. Where permeabilities are high, water may be suitable for industrial use; however, before being used as a public water supply the quality should be checked for excessive concentrations of fluoride.

AIR QUALITY

Air pollution in the basin is currently not a serious problem. The major air pollution problem is from frequent "dust storms"

which occur mostly in the spring of the year. This occurs in large cropland areas or on lands not properly managed and protected.

Pollution from industries in the basin is only minor, nearly all of them meet either state or national ambient air standards.

A more localized problem may occur in the vicinity of livestock feed lots and open refuse dumps. Obnoxious odors may be emitted from these areas to affect the air quality. However, most of the large feed lots chemically treat their waste to reduce this problem.

The Texas Air Control Board has divided the State of Texas into twelve Air Quality Control Regions. The Red River Basin Above Denison Dam is located in Regions I, II, and VIII. Control of air pollution and enforcement of the regulations is done by the Texas Air Control Board.

Region II covers the western part of the Red River Basin. The terrain in the region is relatively level with sparse natural vegetation. The lack of vegetation and terrain result in fairly high surface winds. The prevailing winds in the region are from the southwest in the spring and summer and from the northwest in the fall and winter. The combination of inadequate ground cover and high wind causes dust storms in winter and spring which create an adverse effect on air quality.

The majority of the petroleum and petrochemical industries in the region are located north of Amarillo which is outside the Red River Basin.

The cattle feed lot industry is concentrated around Amarillo although quite a few feed lots are in the Red River Basin. More feed lots are expected to be developed in the basin in the future.

Region I is east of Region II and covers the central portion of the Red River Basin Above Denison Dam. Occasional sand storms occur in the winter and spring. The petroleum and natural gas industries are widely distributed throughout the region.

Region VIII covers the lower portion of the Red River Basin Above Denison Dam. In addition to agriculture, the main source of revenue is crude oil production in the basin. Major refineries are located in Cooke County.

All new industries in the three regions containing the basin are presently in compliance with the Texas Air Control Board Regulations.

The Air Quality Service of the Oklahoma State Health Department monitors and controls the emission of six pollutants: Sulfur Oxides, Particulate Matter, Carbon Monoxide, Photochemical Oxidants, Non-Methane Hydrocarbons, and Nitrogen Oxides. Air Quality Control Regions (AQCR's) are assigned a priority for each pollutant based on measured or anticipated air quality.

Priority I refers to AQCR's which exceed primary ambient air quality standards which have been determined necessary to protect the public health.

Priority II refers to AQCR's which exceed secondary ambient air quality standards which have been determined necessary to protect the public welfare.

Priority III refers to AQCR's in which the air quality is superior to both primary and secondary standards.

The main objective of the Air Quality Service is to obtain and to maintain a Priority III rating for each pollutant in each region throughout the basin. Currently all of the Oklahoma portion of the basin has a priority III rating.

CHAPTER 5

ECONOMIC DEVELOPMENT AND PROJECTIONS

RED RIVER BASIN ABOVE DENISON DAM

CHAPTER 5

ECONOMIC DEVELOPMENT AND PROJECTIONS

INTRODUCTION

This chapter describes the socio-economic base of the Red River Basin Above Denison Dam and desired future conditions. Information is presented about the historical, social, and economic development, the current base which has developed in the Red River Basin Above Denison Dam, and projections of economic activity accompanied by expressions of significant measures desired concerning production, resource use, and conservation. It provides parameters for the projection of economic data on one hand and measures of desired resource conditions on the other. Data concerning water shortages and outdoor recreation reflect the State's view of progressive development. Agricultural production projections are based on U. S. Water Resources Council Projections, which represent the national viewpoint.

This information provides a basis for and quantification of product or condition requirements. These data, compared to the analyses of conditions without accelerated development in Chapter 6, establish quantified needs for development as presented in Chapter 7.

HISTORICAL DEVELOPMENT

For centuries the watersheds of the Red River were covered with grasses and forests. These areas afforded food for buffalo and other game on which the Indian inhabitants depended. The region became part of the United States with the Louisiana Purchase in 1803. Accounts in 1810, 1814, and 1821 of the explorations of Pike, Lewis and Clark, and Stephen H. Long reported the country as being hostile wasteland except for portions along streams, and generally popularized the idea of the great American Desert. However, realization of the basin's potential and population pressures in the East generated gradual settlement. Texas was annexed in 1845 and additional land to the west was ceded to the United States after the Mexican War.

Railroads made possible the occupation of this semi-arid region by wheat and livestock farmers. In the late 19th

century, the production of crops began to dominate the economy and railroads encouraged settlement along their lines with the Homestead Act of 1862, Congress created the Department of Agriculture. Favorable farming weather gave further impetus to settlement. Drouth and meager production in the 1880's with some consequent land abandonment led to development of new techniques of "dry land" farming and interest in irrigation. Farms became larger, more specialized, and more mechanized.

The Federal Government's initial legislative effort in support of reclamation and conservation began in 1894 with the Carey Land Act which provided public lands to certain states for the promotion of irrigation. The Carey Act; however, did not prove satisfactory, and it was not until passage of the Reclamation Act of 1902 that truly effective conservation legislation came into existence. The "black blizzards", the dust storms of the 1930's, impressed upon the Nation once more the need for conservation.

Discovery and production of oil, gas, and other minerals occurred concurrently with development of roads and the auto industry. The trend of population concentration in towns and cities became apparent. The area developed small processing industries with accompanying expansion of suppliers, wholesalers, retailers, and service industries. This development did not include as a prime requirement an abundant quantity of high quality water. Development occurred despite the rather poor quality of water in many streams of the area. Sufficient quantities for drinking and other requirements have been obtained from ground water and clean tributary streams. However, during drouth periods, some cities have been forced to use generally unsuitable water.

A dependable supply of water of adequate quality for its intended use is necessary for basin development.

HUMAN RESOURCES AND THE ECONOMY

Population

The total population of the basin in April 1970 was 781,474. Of this total 429,814 (55 percent) lived in the Oklahoma portion and 351,660 (45 percent) in the Texas portion of the basin. Principal population centers are Amarillo, which lies a short distance outside the basin, and Wichita Falls in Texas, and Lawton, in Oklahoma.

Population of the basin is estimated to have increased from 597,200 in 1910 to 786,890 in 1973, Table 5-1. The basin population increased until 1930, then declined until 1950, then increased again by 1960 and then decreased by 1970. Most of the increase in the Texas portion of the basin occurred in the western or high plains area. Some of this increase can be attributed to irrigation development in the earlier years, followed by added industrial development and associated employment opportunities. There are several large military reservations in the basin. Their presence has probably helped deter a decline in population.

Although there has been an overall increase in basin population over the past 60 years, the rate of increase is less than overall statewide increases for Oklahoma and Texas. Population in both parts of the basin has generally declined relative to their respective States. In 1910 the Oklahoma part of the basin contained about one-fourth of all Oklahomans; by 1970 only one-sixth. Likewise, in the Texas part of the basin, their share of State population dropped from 4.5 percent to 3.1 percent during this period.

Water Resources Council OBERS Series E population projections for the basin are substantially lower than the sum of projections made for the State parts by the Texas Water Development Board and the Oklahoma Employment Security Commission, Table 5-2. The States' projections for 2000 exceed OBERS E by 32 percent. The TWDB projections for 2000 are 62 percent greater than OBERS E and in Oklahoma the OESC projections are 42 percent above OBERS E for a combined total of 51 percent.

Net outmigration occurs when the number of people leaving an area exceeds those moving in plus an allowance for births and deaths. During the two decades prior to 1970, there was a net outmigration of over 145,000 people from the basin, Table 5-3. The high plains area of the Texas portion had an inmigration during the 1950's; however, this amount was more than offset by outmigration from the other Texas counties in the basin. There were only six counties in the basin that had a net inmigration during the 1960's (Marshall and Murray counties in Oklahoma; Grayson, Montague, Deaf Smith, and Randall counties in Texas).

About 69 percent of the basin residents resided in urban areas in 1970, Table 5-4. This is an increase of five percent since 1960. A larger percent of population in the Texas part of the basin live in urban areas than in the Oklahoma part. This is partly due to differences in the size of larger urban areas between the two States. Conversely the Oklahoma part of the basin is more rural, i.e., more people live in

TABLE 5-1

Estimated Total Population

Red River Basin Above Denison Dam

Year	Oklahoma		Texas		Basin Total	
	Number	Percent of Total State	Number	Percent of Total State	Number	Percent of Total States
1910	423,970	25.6	173,230	4.5	597,200	10.8
1920	447,010	22.0	233,220	5.0	680,230	10.1
1930	528,590	22.1	301,510	5.2	830,100	10.1
1940	472,410	20.2	283,825	4.4	756,235	8.6
1950	421,860	18.9	313,330	4.1	735,190	7.4
1960	433,730	18.6	360,520	3.8	794,250	6.7
1970	429,814	16.8	351,660	3.1	781,474	5.7
1973	437,380	-	349,510	-	786,890	-

Source: U. S. Census of Population Reports for Oklahoma and Texas. Data were adjusted to basin area for 1970; other years based upon trends of representative counties.

TABLE 5-2

Comparison of Population Projections

Red River Basin Above Denison Dam

Area	Source 1/	1970	2000	2020
			Numbers	
Oklahoma	OBERS E	429,814	435,200	459,300
	OESC	429,814	576,486	650,833
Texas	OBERS E	351,660	351,100	361,700
	TWDB	351,660	465,350	585,687
Basin	OBERS E	781,474	786,300	821,000
	OESC & TWDB	781,474	1,041,836	1,236,520
State of Oklahoma	OBERS E	2,559,463	3,144,700	3,445,400
	OESC	2,559,463	3,773,000	4,429,000
State of Texas	OBERS E	11,196,730	14,632,600	16,607,200
	TWDB	11,196,730	18,146,100	25,029,200
			Percent 2/	
Oklahoma	OBERS E	16.8	13.8	13.3
	OESC	16.8	15.3	14.7
Texas	OBERS E	3.1	2.4	2.2
	TWDB	3.1	2.6	2.4
Basin Percent of Two States	OBERS E	5.7	4.4	4.1
	OESC & TWDB	5.7	4.8	4.2

Source: 1/ OBERS E - Office of Business Economics, U. S. Department of Commerce and Economic Research Service, U. S. Department of Agriculture.
OESC - Oklahoma Employment Security Commission.
TWDB - Texas Water Development Board.

2/ Basin portion as a percent of respective state total.

TABLE 5-3

Net Migration of Population

Red River Basin Above Denison Dam

Area	Net Migration			
	1950-1960		1960-1970	
	Number	Percent	Number	Percent
Basin	- 47,204	-6.4	- 98,464	-12.4
Texas	- 5,920	-1.9	- 50,803	-14.1
Oklahoma	- 41,284	-9.8	- 47,661	-11.0
State of Oklahoma	-218,553	-9.8	+ 13,349	+ 0.6
State of Texas	+113,831	+1.5	+213,194	+ 2.2

Sources: (1) Net Migration of the Population, 1950-1960, By Age, Sex, and Color. Volume 1, Part 5, May 1965, Economic Research Service, USDA. (2) Population Change and Net Migration by Counties in the Great Plains States, 1960-1970. Great Plains Agricultural Council Report No. 52, Stanley Voelker, Economic Development Division, Economic Research Service, USDA, Fargo, North Dakota.

TABLE 5-4

Population by Residence

Red River Basin Above Denison Dam

Area	1970				1960	
		Rural				
	Urban	In Places of 1,000-2,500	Rural Farm	Other	Urban	Rural
	Percent					
Basin	68.9	7.0	8.5	15.6	64.1	35.9
Texas	77.6	4.6	6.3	11.5	75.4	24.6
Oklahoma	58.6	9.8	11.0	20.6	50.7	49.3
State of Oklahoma	68.0	5.9	7.8	18.3	62.9	37.1
State of Texas	79.7	3.5	4.2	12.6	75.0	25.0

Source: U. S. Census of Population Reports for Oklahoma and Texas.

towns with less than 2,500 residents, outside of city limits or on farms.

The median age of basin residents is about 29 years. This is slightly less than for all of Oklahoma, but greater than for the State of Texas, Table 5-5. The basinwide percentage of people over 65 years of age is higher than that of the States as a whole. It should also be noted that the median age for female basin residents is about 5 years greater than for males. Part of this difference can be attributed to the longer life expectancy for females.

TABLE 5-5

Population Age Groups

Red River Basin Above Denison Dam

Age Group	Basin			State Total	
	Male	Female	Total	Oklahoma	Texas
	Percent				
Under 16	29.6	28.3	28.9	28.9	31.8
16-24	18.6	14.0	16.3	15.5	16.3
25-44	21.5	22.4	22.0	22.9	24.0
45-64	19.9	21.6	20.7	21.0	19.1
Over 65	10.4	13.7	12.1	11.7	8.8
	Years				
Median Age	26.6	31.6	29.0	29.4	26.4

Source: U. S. Census of Population Reports, 1970.

There is a greater disparity in years of school completed between residents in the Texas part of the basin and the entire State of Texas than comparable measures for Oklahoma residents, Table 5-6. Approximately half of the basin residents that are 25 years of age or older have completed high school. This is slightly less than for the entire State of Oklahoma but considerably greater than for the same age group in all of Texas. A similar situation is evident for college graduates.

The number of years of formal education does not always reflect how well workers are trained to perform their jobs. Some

TABLE 5-6

Selected Education Characteristics

Red River Basin Above Denison Dam

(1970)

Item	Unit	Basin			State of Oklahoma	State of Texas	United States
		Oklahoma	Texas	Total			
All persons age 25 or more less than 1 year of high	Pct.	32.9	26.3	30.0	29.5	39.4	27.8
High school graduate	Pct.	46.8	50.3	48.4	51.6	35.9	52.3
College graduate	Pct.	7.6	10.1	8.8	10.0	5.8	10.7
Median years of school	Yrs.	11.5	12.0	11.8	12.1	10.3	12.1
All persons 18-24 years old high school graduate	Pct.	62.4	66.2	64.0	67.2	48.6	66.5
College graduate	Pct.	8.2	5.6	7.1	6.2	3.8	6.2

Source: U. S. Department of Labor, Manpower Administration Summaries of the 1970 U. S. Census of Population, and U. S. Census of Population, 1970.

individuals have the innate capacity to acquire sufficient skills to successfully accomplish their tasks. Also, not all occupations require the same amount as well as type of instruction. Recently, there is added emphasis on vocational training in lieu of formal college instruction. Workers who will enter into some of the trade, operative, craft, and service sectors find that vocational training is best suited for them.

Employment

Total labor force of the basin was estimated at 313,806 in 1970, Table 5-7. This consists of residents 16 years of age and older, both civilian and military, who are employed as well as those currently unemployed but seeking a job. The major portion of the labor force is in the 25-64 age group. They are gradually becoming a larger part because there is a tendency for younger people to pursue educational opportunities and acquire job skills before entering the labor force. Also, improved retirement benefits have influenced older workers to withdraw from the labor force at an earlier age.

The residents over age 16 and not in the labor force consists mainly of housewives, students, retired workers, disabled and inmates of institutions.

In 1970, unemployment rates for the U. S., Texas and Oklahoma were 4.4 percent, 3.6 percent and 4.2 percent, respectively. This rate for the basin was 4 percent which compares favorably with the State and national figures.

In addition to the unemployed, there are workers whose labor input is underutilized, thus their income is less than it might be. The unemployed component of the labor force includes those who cannot find work, whereas the underemployed includes those who are employed, but at an amount less than they prefer.

One method for measuring underemployment is to determine whether or not workers' income is below capacity. Income capacity is measured by age, educational status and other selected attributes of the labor force within each county. They are compared with similar indicators for the Nation as a whole. In 1960, the underemployment rates for the Texas and Oklahoma portions of the basin were estimated at 17.6 percent and 20.9 percent, respectively. Severe underemployment occurs when the rate exceeds 20 percent. Comparable estimates for 1970 are not available.

The 1970 U. S. Census of Population reports provide some insight as to the amount of underemployment by counting the number

TABLE 5-7

Labor Force and Employment Status

Red River Basin Above Denison Dam

(1970)

Item	Unit	Oklahoma	Texas	Basin		
				Male	Female	Total
Population 16 and over	No.	308,478	247,120	273,890	281,708	555,598
Total Labor Force	No.	168,446	145,360	210,890	102,817	313,806
Labor Force Participation	Pct.	54.6	58.8	77.0	36.5	56.5
Civilian Labor Force	No.	139,455	132,226	169,935	101,746	271,681
Employed	No.	133,049	127,846	164,624	96,271	260,895
Unemployed	No.	6,406	4,380	5,311	5,475	10,786
Unemployment Rate	Pct.	4.6	3.3	3.1	5.4	4.0
Not in Labor Force	No.	140,032	101,760	62,901	178,891	241,792
Inmate of Institutions	No.	6,930	4,496	5,453	5,973	11,426
Enrolled in School	No.	15,433	15,058	14,142	16,349	30,491
Other under Age 65	No.	75,100	54,025	17,112	112,013	129,125
Disabled or Handicapped	No.	18,118	9,764	10,080	17,802	27,882
Other over Age 65	No.	42,569	28,181	26,194	44,556	70,750

Source: U. S. Department of Labor, Manpower Administration Summaries of the 1970 U. S. Census of Population.

of weeks worked in the previous year, Table 5-8. This includes all persons 16 years of age and older who worked in 1969. Approximately 19 percent of the employed worked half of the year or less. This implies that underemployment continues as an undesirable social condition in the basin.

TABLE 5-8

Number of Weeks Worked by the Employed

Red River Basin Above Denison Dam

(1969)

Number of Weeks Worked	Oklahoma	Texas	Basin
	-------------	Percent	-------------
50-52	60.1	62.7	61.3
40-49	11.4	9.9	10.7
27-39	9.1	8.5	8.9
14-26	8.5	7.9	8.2
Less than 14	10.9	11.0	10.9

Source: U. S. Department of Labor, Manpower Administration Summaries of the 1970 U. S. Census of Population reports.

Employment in the basin increased from 203,228 in 1940 to 260,895 in 1970, Table 5-9. The increase in nonfarm employment opportunities more than offset the decline in agricultural employment. The latter is the only major industry where employment declined continuously over the 30-year period. It should be recognized that employees of agriculturally related firms are not included with agricultural employment, but appear in manufacturing, distributive, and service categories. Employment in the transportation, construction, and mining sectors declined between 1960-1970 after two decades of continuous growth. All other sectors have expanded since 1940.

Basic industries of the area include agriculture, mining, and manufacturing. In 1940, they provided 51 percent of all jobs; in 1950, 40 percent; in 1960, 31 percent; and in 1970, only 26 percent.

Male employees accounted for 164,623 or 63 percent of all job holders in 1970. Female employment has probably expanded more

TABLE 5-9

Estimated Civilian Employment by Major Sectors

Red River Basin Above Denison Dam

Major Sectors	OKLAHOMA 1940 Number	1940 Percent	1950 Number	1950 Percent	1960 Number	1960 Percent	1970 Number	1970 Percent
Civilian Employment	121,208	100.00	131,672	100.00	128,792	100.00	133,049	100.00
Agriculture, Forestry & Fisheries	58,723	48.45	42,043	31.93	23,017	17.87	14,616	10.98
Mining	3,194	2.64	8,919	6.77	7,583	5.89	6,331	4.76
Construction	4,096	3.38	9,523	7.23	10,581	8.22	9,683	7.28
Manufacturing	4,111	3.39	6,088	4.62	9,983	7.75	14,284	10.73
Transportation	2,886	2.38	4,001	3.04	4,248	3.30	3,494	2.63
Communications & Public Utilities	1,658	1.37	3,253	2.47	3,867	3.00	3,963	2.98
Wholesale Trade	2,790	2.30	3,609	2.74	3,366	2.61	3,785	2.84
Retail Trade	17,009	14.03	22,497	17.09	25,282	19.63	25,917	19.48
Finance, Insurance & Real Estate '	2,004	1.65	2,695	2.05	3,678	2.68	4,906	3.69
Services	21,569	17.80	23,864	18.12	29,057	22.56	36,255	27.25
Public Administration	3,168	2.61	5,180	3.94	8,130	6.31	9,815	7.38

Major Sectors	TEXAS 1940 Number	1940 Percent	1950 Number	1950 Percent	1960 Number	1960 Percent	1970 Number	1970 Percent
Civilian Employment	82,020	100.00	107,733	100.00	127,439	100.00	127,846	100.00
Agriculture, Forestry & Fisheries	25,521	32.34	24,027	22.30	19,024	14.93	14,879	11.64
Mining	7,089	8.64	8,320	7.72	8,429	6.61	3,818	2.99
Construction	3,589	4.38	9,016	8.37	10,690	8.39	7,892	6.17
Manufacturing	4,866	5.93	7,151	6.64	10,679	8.38	14,991	11.73
Transportation	3,245	3.96	4,910	4.56	4,945	3.88	4,230	3.31
Communications & Public Utilities	1,468	1.79	3,157	2.93	4,282	3.36	4,252	3.32
Wholesale Trade	2,256	2.75	3,642	3.38	4,886	3.83	5,490	4.29
Retail Trade	13,173	16.06	20,262	18.81	24,073	18.89	24,398	19.08
Finance, Insurance & Real Estate '	1,816	2.21	2,755	2.56	4,667	3.66	5,407	4.23
Services	16,050	19.57	20,608	19.13	28,875	22.66	34,626	27.09
Public Administration	1,947	2.37	3,885	3.60	6,889	5.41	7,863	6.15

Major Sectors	BASIN TOTAL 1940 Number	1940 Percent	1950 Number	1950 Percent	1960 Number	1960 Percent	1970 Number	1970 Percent
Civilian Employment	203,228	100.00	239,405	100.00	256,231	100.00	260,895	100.00
Agriculture, Forestry & Fisheries	85,244	41.94	66,070	27.60	42,041	16.41	29,495	11.30
Mining	10,283	5.06	17,239	7.20	16,012	6.25	10,149	3.89
Construction	7,685	3.78	18,539	7.74	21,271	8.30	17,575	6.74
Manufacturing	8,977	4.42	13,239	5.53	20,662	8.06	29,275	11.22
Transportation	6,131	3.02	8,911	3.72	9,193	3.59	7,724	2.96
Communications & Public Utilities	3,126	1.54	6,410	2.68	8,149	3.18	8,215	3.15
Wholesale Trade	5,046	2.48	7,251	3.03	8,252	3.22	9,275	3.55
Retail Trade	30,182	14.85	42,759	17.86	49,355	19.26	50,315	19.29
Finance, Insurance & Real Estate '	3,820	1.88	5,450	2.27	8,345	3.26	10,313	3.95
Services	37,619	18.51	44,472	18.58	57,932	22.61	70,881	27.17
Public Administration	5,115	2.52	9,065	3.79	15,019	5.86	17,678	6.78

Source: Derived from U.S. Census of Population Reports.

rapidly than for males. Farmers' wives typically are not counted as part of the labor force although they may contribute significantly to agricultural production. However, as farm women seek off-farm employment, or as they migrate from farms to towns or urban areas, they often become a part of the labor force. Also, there is a tendency for some women who have finished rearing their families to find jobs in service-type industries. More of these jobs have become available and quite often they can be filled by workers with very little specialized training.

Income and Earnings

Income is but one expression of measuring the economic well-being of people. Income data can be useful as a gauge to compare the purchasing power of basin residents to that of other areas.

Family income by income groups is shown in Table 5-10. Median income for all basin families in 1969 was $7,153 as compared to $9,586 for the Nation. Median family income for the Oklahoma part of the basin was considerably less than for families in the Texas portion.

Per capita personal income for basin residents increased from $1,710 in 1950 to $3,080 in 1971, Table 5-11. The latter is about 87 percent of the national average. During the 1950-1971 period, per capita income in the Oklahoma part of the basin rose from 66 percent to 81 percent of the national average, meanwhile comparable figures for the Texas part of the basin declined from 106 percent to 92 percent.

Per capita income projections based upon OBERS E total personal income and population projections are also shown in Table 5-11. By 2000, basin per capita income is projected to increase to $7,257 and $12,056 by 2020. Total personal income for the basin rose from $1.3 billion in 1950 to $2.4 billion in 1970, Table 5-12. This change reflects an increase in real purchasing power because the data has been adjusted to remove the effect of price inflation. From 1950 to 1970, total personal income rose 119 percent in the Oklahoma part of the basin and 67 percent in the Texas part as compared to 127 percent for the Nation, 116 percent for all of Oklahoma and 145 percent for the State of Texas.

Wages, salaries, proprietors income, and other labor income are collectively referred to as earnings. They accounted for 74 percent of total personal income in 1970 as compared to 81 percent two decades earlier. Thus, property income and net transfer payments (the remaining items that are a part of total personal income) are increasing at a more rapid rate.

TABLE 5-10

Family Income By Groups

Red River Basin Above Denison Dam

(1969)

Item	Basin			State of Oklahoma	State of Texas	United States
	Oklahoma	Texas	Total			
	Percent					
Family Income Groups						
Less than $3,000	19.2	12.6	16.2	15.6	13.1	10.3
$3,000 - $4,999	17.0	14.0	15.6	13.9	12.5	10.0
$5,000 - $6,999	17.7	16.1	17.0	15.1	13.8	11.9
$7,000 - $9,999	20.9	21.9	21.4	21.3	20.7	20.6
$10,000 - $14,999	16.8	21.4	18.9	21.2	23.4	26.6
$15,000 - $24,999	6.6	10.5	8.3	10.1	12.7	16.0
Over $25,000	1.8	3.5	2.6	2.8	3.8	4.6
Families Below 1/						
Low Income Level	18.2	12.6	15.6	15.1	14.7	10.7
125 Percent of Low Income Level	26.5	18.9	22.9	21.6	20.4	15.0
	Dollars					
Median Family Income	7,153	6,555	7,895	7,720	8,486	9,586

1/ Low income level is a measure of minimum amount of income that is needed to provide a nutritionally adequate food plan for the average size family.

Source: For the Basin: U.S. Department of Labor, Manpower Administration Summaries. For the States Oklahoma and Texas and the U.S.: U.S. Department of Commerce, County and City Data Book, 1972

TABLE 5-11

Per Capita Personal Income

Red River Basin Above Denison Dam

Year	Basin			State of Oklahoma	State of Texas
	Oklahoma	Texas	Total		
	1967 Dollars				
1950	1,353	2,189	1,710	1,580	1,861
% of U.S.	66	106	83	77	90
1960	1,879	2,305	2,073	2,038	2,161
% of U.S.	77	94	85	84	89
1962	1,880	2,402	2,165	2,115	2,229
% of U.S.	73	93	84	82	86
1967	2,573	2,995	2,799	2,695	2,831
% of U.S.	81	94	88	85	89
1968	2,632	3,003	2,832	2,788	2,977
% of U.S.	79	90	85	85	90
1969	2,785	3,102	2,956	2,878	3,074
% of U.S.	81	90	86	84	89
1970	2,907	3,280	3,075	2,964	3,158
% of U.S.	84	94	88	85	91
1971	2,863	3,263	3,080	3,013	3,173
% of U.S.	81	92	87	85	90
2000 1/	6,944	7,646	7,257	7,200	7,500
% of U.S.	85	94	89	89	93
2020 1/	11,644	12,575	12,056	12,000	12,400
% of U.S.	88	95	91	91	94

1/ OBERS Series E Projections.

Source: U.S. Department of Commerce, Office of Business Economics, Regional Economics Information System. Data adjusted to the basin.

TABLE 5-12

Total Personal Income and Earnings for Selected Years
and OBERS Series E Projections

Red River Basin Above Denison Dam

Year / Item	Oklahoma		Texas		Basin Total	
	Dollars 1/	Percent 2/	Dollars 1/	Percent 2/	Dollars 1/	Percent 2/
1950						
Personal Income	570.8		687.7		1,258.4	
Earnings	446.7	78	567.5	83	1,014.3	81
1960						
Personal Income	815.0		831.5		1,646.5	
Earnings	649.5	80	666.6	80	1,316.0	80
1965						
Personal Income	1,000.0		988.1		1,988.1	
Earnings	759.5	76	746.0	76	1,505.5	76
1968						
Personal Income	1,181.5		1,104.0		2,285.5	
Earnings	879.3	74	840.7	76	1,720.0	75
1970						
Personal Income	1,249.5		1,153.4		2,402.9	
Earnings	916.6	73	861.9	75	1,778.5	74
2000						
Personal Income	3,022.0		2,676.9		5,698.9	
Earnings	2,132.0	71	1,928.8	72	4,060.8	71
2020						
Personal Income	5,349.5		4,548.4		9,897.8	
Earnings	3,800.4	71	3,293.3	72	7,093.7	72

1/ Millions of 1967 dollars.
2/ Earnings as a percent of personal income.

Source: Derived from U.S. Department of Commerce, Office of Business Economics, Regional Economcis Information System data.

Total personal income for the basin is projected to increase from \$2.4 billion in 1970 to \$5.7 billion in 2000 and \$9.9 billion in 2020.

Earnings by major sectors for the United States, Texas, Oklahoma, and the basin are shown in Table 5-13. These data are expressed as a percent of total personal income for selected years including projections for 2000 and 2020. Farm earnings in the basin accounted for 19.4 percent of total personal income in 1950 as compared to about seven percent for the Nation. This measure is projected to decrease to 3.4 percent for the basin and 0.8 percent for the Nation by 2020.

TABLE 5-13

Historical and Projected Earnings by Sectors as a Percentage of Total Personal Income

Red River Basin Above Denison Dam

Sector / Year	Basin			State of Oklahoma	State of Texas	United States
	Oklahoma	Texas	Total			
	---- Percent ----					
Farm						
1950	19.6	19.2	19.4	11.9	11.3	7.2
1960	12.0	10.6	11.3	6.5	6.8	3.7
1970	10.8	8.4	9.7	4.3	5.2	2.5
2000	5.1	4.3	4.7	1.5	2.[illegible]	1.2
2020	3.7	3.1	3.4	1.0	1.4	.8
Government (Inc. Military)						
1950	15.7	14.1	14.8	11.3	11.5	9.4
1960	26.2	16.9	21.5	13.6	15.6	11.6
1970	28.3	17.0	23.2	15.1	17.9	14.0
2000	27.0	16.5	22.1	14.7	17.8	14.6
2020	27.8	17.1	22.9	15.2	18.7	15.2
Mining & Construction						
1950	8.2	10.6	9.5	11.4	13.1	6.6
1960	9.1	9.8	9.5	10.0	12.4	6.2
1970	4.9	5.0	5.0	7.9	8.4	5.7
2000	3.8	4.4	4.1	5.7	5.7	4.9
2020	3.5	4.0	3.7	5.0	4.9	4.5
Manufacturing						
1950	5.7	5.9	5.8	11.7	9.1	23.9
1960	6.6	7.1	6.9	15.1	11.0	24.8
1970	7.4	10.3	8.8	16.3	12.9	22.1
2000	9.3	11.2	10.4	15.5	13.4	18.0
2020	9.8	11.2	10.4	14.4	13.0	16.3
Trade						
1950	15.5	15.6	15.5	16.8	16.5	15.6
1960	11.7	15.6	13.7	16.0	14.6	14.7
1970	8.8	13.7	11.2	14.6	12.1	13.1
2000	8.5	11.3	9.8	12.8	10.7	11.3
2020	7.9	10.3	9.0	11.8	9.8	10.4
Services						
1950	7.5	7.9	7.7	8.9	8.5	9.2
1960	5.8	9.4	8.1	10.0	9.0	10.5
1970	7.2	11.5	9.2	11.6	10.0	12.0
2000	10.5	15.0	12.6	16.3	14.3	16.7
2020	12.2	17.2	14.5	18.3	16.2	18.7
Other						
1950	6.1	9.2	7.9	10.6	9.9	10.6
1960	7.3	10.8	8.9	11.2	10.3	10.8
1970	5.5	8.8	5.9	9.8	9.1	10.0
2000	5.9	9.4	7.6	10.8	9.9	10.2
2020	[illegible]	9.5	7.8	11.0	9.8	10.4

Source: Prepared from U.S. Department of Commerce, Office of Business Economics, Regional Economics Information System and OBERS E, Water Resources Council Reports.

SELECTED MAJOR INDUSTRIAL GROUPS

Manufacturing

Most of the manufacturing activity in the basin occurs in or near the larger population centers. "Value added" is a measure of the increased utility of a product due to some kind of manufacturing process. Value added is derived by reducing the value of manufacturing shipments by the total costs associated with the manufactured product, Table 5-14.

Manufacturing plants in the basin turn out a variety of items such as clothing and apparel, lumber and wood, printing, machinery, transportation equipment, petroleum products, food and kindred products. Oil, gas, gravel, stone and crop and livestock products are the major raw materials produced in the basin which are further refined and processed locally. Livestock feed processing and slaughter plants have become more numerous following the dramatic increase in commercial cattle feed lots in the high plains area of the basin. Cottonseed, guar, sunflowers, and mung beans are processed in oil extraction plants. Horse trailers and oil field equipment are also manufactured in the basin.

TABLE 5-14

Value Added by Manufacturing

Red River Basin Above Denison Dam

Year	Oklahoma	Texas	Basin Total
	(Million $ 1967)		
1947	22.3	84.6	106.9
1954	42.5	77.2	119.7
1958	44.4	88.5	132.9
1963	35.2	77.4	112.6
1967	52.0	138.5	190.5
1972	122.6	205.6	328.2

1/ Numerous sources are not reported to avoid disclosure of individual data.

Source: U. S. Census of Manufacturers for various years.

Agriculture

Agriculture is one of the most important segments of the basin economy. Although the number of farm and farm operators is declining, agriculture has been an expanding industry. It is expanding in terms of total value of production as well as product diversification. The inverse relationship between increased production and declining farm numbers stems largely from an increase in farm efficiency through the use of conservation programs, resource developments, improved technology, feed additives, fertilizers, insecticides, and larger farm machinery. Further efficiencies can be expected in the future.

Larger quantities of agricultural products will be required as the population of the Nation increases as well as net exports to foreign countries increase. Rising per capita income leads to additional expenditures for many food items. As real income rises, consumers tend to modify their diets and this often means eating more meat, especially beef. Beef production is the principal source of livestock income to the basin. Prior to the early 1960's, most of the cattle industry centered on cow-calf operations and winter grazing for feeder cattle. By the mid 1960's commercial cattle feeding was rapidly expanding in the western part of the basin, particularly the high plains area of Texas. Currently this area (both within and adjacent to the basin) is one of the major cattle feeding areas of the Nation.

Wheat, grain sorghum, cotton, peanuts, hay, small grains, and soybeans are the major crops grown in the basin. However, vegetables, guar, mung beans, sugar beets, silage, castorbeans, and sunflowers are also grown. Pastureland and rangeland are the major land uses in terms of acres. Most of the forest land in the basin provides grazing for livestock and wildlife.

Farm Numbers and Sizes: The trend in numbers of farms within the basin has varied at times as compared to that observed nationally. Farm numbers increased by 4.5 percent between 1964 and 1969; however, they decreased 13.8 percent by 1974, Table 5-15. Since 1950 farm numbers have declined 46 percent in the Oklahoma part of the basin, 36 percent in the Texas part and 42 percent for the basin. This compares with 48 percent for the State of Oklahoma and 44 percent for Texas.

As farm numbers declined the average size of farms increased. In 1974 the average size in the Oklahoma part of the basin was 480 acres as compared to 1,033 acres in the Texas part, this compares with 444 acres and 913 acres in 1969, respectively.

TABLE 5-15

Historical Record of Farm Numbers

Red River Basin Above Denison Dam

Area	1950	1954		1959		1964		1969		1974	
	Number	Number	% Change	Number	% Change	Number	% Change	Number	% Change	Number	% Change
Oklahoma	34,887	29,419	-15.7	23,724	-19.4	21,927	- 7.6	21,828	- .4	18,959	-13.1
Texas	19,820	17,475	-12.2	14,650	-16.2	13,039	-11.0	14,785	+13.4	12,604	-14.8
Total Basin	54,707	46,894	-14.3	38,374	-18.2	34,966	- 8.9	36,613	+ 4.7	31,563	-13.8
State of Oklahoma	142,246	118,979	-16.4	94,676	-20.4	88,726	- 6.3	83,037	- 6.4	73,649	-11.3
State of Texas	331,567	292,947	-11.6	227,071	-22.5	205,110	- 9.7	213,550	+ 4.1	185,572	-13.1
U.S. 1/	5,388	4,782	-11.1	3,711	-22.6	3,158	-14.9	2,730	-13.5	2,450	-10.3

1/ Farm numbers for the U. S. are shown in thousands.

Source: Various U. S. Census of Agriculture reports.

The distribution of farm numbers by size categories is shown in Table 5-16. Basinwide there has been a relative increase in farms under 10 acres in size and as well as those over 1,000 acres. There has been a notable decrease in farms within the 180-499 acre category. All other categories have remained quite stable.

A reduction in farm numbers is prime evidence that the rural farm population is also declining. There are a variety of reasons why people leave the farm. One cause is the capital requirements needed for a successful farming operation. The value of agricultural land and improvements as well as the cost of machinery and power equipment to operate the land is increasing.

TABLE 5-16

Distribution of Farms by Size Categories
Red River Basin Above Denison Dam

Size Category	Oklahoma			Texas			Basin Total		
	1964	1969	1974	1964	1969	1974	1964	1969	1974
Acres	Percent								
1- 9	1.8	4.0	4.3	1.8	4.5	4.8	1.8	4.2	4.5
10- 49	8.4	7.0	7.8	5.7	5.9	6.7	7.5	6.6	7.3
50- 179	29.5	29.1	28.8	18.0	19.4	20.6	25.4	25.2	25.5
180- 499	35.6	33.7	31.2	33.5	29.7	25.9	34.8	32.2	29.1
500- 999	16.7	17.0	16.8	21.8	21.6	20.6	18.6	18.8	18.3
1,000-1,999	6.1	7.0	8.4	11.5	11.8	12.8	8.0	8.9	10.2
Over 2,000	1.9	2.2	2.7	7.6	7.1	8.6	4.0	4.1	5.1

Source: U. S. Census of Agriculture reports.

In 1969, the value of farm land and buildings for the basin was \$3.4 billion or about \$89,000 per farm, Table 5-17. By 1974 the total increased to nearly \$5.3 billion or about \$167,000 per unit.

TABLE 5-17

Value of Land and Buildings, and
Machinery and Equipment

Red River Basin Above Denison Dam

Area / Year	Value of Land & Buildings Per Farm	Value of Land & Buildings Per Acre	Value of Machinery & Equipment Per Farm
	--------------------Dollars--------------------		
Oklahoma Portion			
1969	72,268	163	8,267
1974	138,970	290	15,902
Texas Portion			
1969	114,250	129	10,577
1974	209,651	203	26,750
Basin			
1969	88,981	144	9,211
1974	167,195	239	19,410
State of Oklahoma			
1969	74,838	173	7,597
1974	139,119	307	14,637
State of Texas			
1969	99,133	148	8,293
1974	184,649	252	15,154

Source: U. S. Census of Agriculture Reports.

Agricultural Sales and Production: Crop and livestock production are both important contributors to the basin's gross agricultural sales. Prior to 1969, livestock sales accounted for about one-third the value of all farm products sold, Table 5-18. By 1969 and continuing to 1974, sales from livestock and livestock products had increased to at least two-thirds of the value of all farm products sold. This dramatic increase in the relative importance of livestock is largely due to increased production within the basin, particularly in the Texas high plains. Several large commerical feed lots are located in the basin, each having a capacity to finish several thousand head of feeder cattle.

The above situation is somewhat reversed in the Oklahoma part of the basin where crops sales have exceeded livestock sales in each of the census years except 1969.

TABLE 5-18

Value of Agricultural Sales

Red River Basin Above Denison Dam

		Value of All Farm Prod. Sold	Value of Crops Sold	Value of Livestock Sold	Percent of State(s) 1/		
					Value of All Farm Prod. Sold	Value of Crops Sold	Value of Lvstk. & Lvstk. Prod. Sold
		---(000) 2/-					
1949:	Basin	353,514	236,969	116,545	15.9	17.1	14.0
	Oklahoma Portion	148,525	96,059	52,466	31.5	37.7	24.3
	Texas Portion	204,989	140,910	64,079	11.7	12.4	10.4
1954:	Basin	313,149	218,766	94,383	15.0	16.5	12.4
	Oklahoma Portion	131,338	86,126	45,212	31.4	38.9	23.1
	Texas Portion	181,811	132,640	49,171	10.9	12.0	8.7
1959:	Basin	399,246	232,999	166,247	14.3	16.2	12.3
	Oklahoma Portion	177,259	92,144	85,115	29.3	35.4	24.8
	Texas Portion	221,987	140,855	81,132	10.1	11.9	8.0
1964:	Basin	446,787	260,986	185,801	15.0	17.2	12.9
	Oklahoma Portion	184,414	99,919	84,495	29.2	37.1	23.3
	Texas Portion	262,373	161,067	101,306	11.2	12.9	9.4
1969:	Basin	726,412	203,881	522,531	18.2	17.2	18.7
	Oklahoma Portion	240,048	87,103	152,945	26.5	34.8	23.4
	Texas Portion	486,364	116,778	369,586	15.8	12.6	17.3
1974:	Basin	778,061	280,101	497,960	20.7	18.9	21.8
	Oklahoma Portion	227,778	120,861	106,917	27.9	35.0	22.7
	Texas Portion	550,283	159,240	391,043	18.7	14.0	21.5

1/ The basin total as a percent of Texas plus Oklahoma and the respective state portions of the basin as percents of the respective state totals.
2/ 1967 dollars.
Source: U.S. Census of Agriculture reports.

Wheat and grain sorghum are the two most important crops grown basinwide in terms of value of production, Table 5-19. Cotton, pasture and range, peanuts, hay crops, small grains and oil crops are also important. Value of production is based upon units of production multiplied by the price per unit of output for each of the State parts.

Approximately two-thirds of the value of production from cropland in the Texas portion is produced under irrigated conditions, whereas in the Oklahoma portion only one-eighth is produced on irrigated land.

Forest Products Industry

For the purpose of this study, the forest product industry is defined as (1) a primary sector consisting of lumber and wood products, (2) a secondary sector consisting of furniture and fixtures and (3) paper and allied products. In this report, these sectors are related to the number of establishments, total employment and income, cost of materials, and new capital expenditures.

In this basin, rising labor costs and the scarcity of timber have not had an adverse effect on the number of forest product industries. In fact, they have shown an increase. The primary and secondary sectors have increased by 45 percent from 1947 to 1972; furniture and fixtures by 27 percent; and paper and allied products by 63 percent, Table 5-20.

The lumber and wood products industry performs cutting, logging, and milling operations resulting in products such as lumber, pallets, poles, crossties, and other basic wood materials. This industry provided annual employment for 1,900 persons in 1972, making up about 70 percent of the employment in the basin's wood-using manufacturing sector within the basin. Annual payroll for these groups totaled $11.1 million, or 64 percent of the wood-using industry payroll, Table 5-21.

The furniture and fixture industry includes those firms engaged primarily in manufacturing household furniture, T. V. cabinets, office furniture, partitions, fixtures, and other items made at least partly from wood. Eleven establishments, or 31 percent of the basin's wood industry were manufacturing furniture and fixtures which provided 200 jobs with a payroll of $1.2 million in 1972.

TABLE 5-19

Current 1/ Agricultural Production

Red River Basin Above Denison Dam

Land Use	Production Unit	Oklahoma Acres	Oklahoma Production	Oklahoma Value	Texas Acres	Texas Production	Texas Value	Value for Total 5/ Basin
		------------	------------	----------000	------------	------------	------------	---$000---
Cropland		3,438.5	-	226,048.3	5,166.9	-	398,785.6	624,833.9
Nonirrigated		3,281.1	-	194,377.2	3,773.3	-	136,090.6	330,467.8
Wheat	bu	1,322.0	30,118.4	98,185.9	741.9	13,765.8	42,261.0	140,447.0
Grain Sorghum	bu	153.8	5,074.1	12,045.9	273.7	7,538.2	17,518.8	29,564.7
Cotton	lb/lint	396.4	112,383.1	43,829.4	394.6	100,471.7	40,188.5	84,017.9
Peanuts	lb	24.7	45,452.4	8,090.5	2.1	2,470.0	432.3	8,522.8
Alfalfa	ton	175.8	407.9	22,433.0	31.9	78.0	4,287.7	26,720.8
Other Hay	ton	-	-	-	151.3	325.2	14,307.3	14,307.3
Barley-Oats	bu	-	-	-	60.0	3,356.7	5,605.7	5,605.7
Crop Pasture	AUM	642.9	1,088.0	9,792.4	754.7	1,276.6	11,489.2	21,281.6
Other 2/		565.5	-	-	1,363.1	-	-	-
Irrigated		157.4	-	31,671.1	1,393.6	-	262,695.0	294,366.1
Wheat	bu	16.0	576.9	1,880.6	314.8	11,370.8	34,908.4	36,789.0
Grain Sorghum	bu	14.7	820.3	1,947.3	587.7	60,995.5	141,753.5	143,700.8
Cotton	lb/lint	50.4	24,449.8	9,535.4	197.0	98,378.4	39,351.4	48,886.8
Peanuts	lb	22.2	67,221.7	11,965.5	3.2	8,570.0	1,499.7	13,465.2
Alfalfa	ton	24.1	115.3	6,342.3	32.9	157.8	8,679.3	15,021.5
Other Hay	ton	-	-	-	14.6	55.8	2,453.4	2,453.4
Barley-Oats	bu	-	-	-	9.2	852.8	1,440.9	1,440.9
Soybeans	bu	-	-	-	33.2	996.6	4,933.4	4,933.4
Silage	ton	-	-	-	33.[illegible]	692.5	11,073.[illegible]	11,073.[illegible]
Sugarbeets	ton	-	-	-	14.4	303.9	9,039.4	9,039.4
Crop Pasture	AUM	-	-	-	109.8	839.5	7,555.8	7,555.8
Other 2/		30.0	-	-	43.6	-	-	-
Pasture		960.7	4,101.7	36,914.9	266.4	1,025.1	9,233.3	46,149.7
Nonirrigated	AUM	926.6	3,820.3	34,382.6	204.0	624.4	5,61[illegible].9	40,002.5
Irrigated	AUM	34.1	28[illegible].4	2,532.3	62.4	4[illegible].7	3,614.9	6,147.2
Range	AUM	4,174.8	2,049.8	18,448.4	7,994.2	3,43[illegible].7	31,055.9	49,504.2
Forest		768.3		2,63[illegible].5	108.3			2,942.[illegible]
Grazing	AUM		289.0	2,600.6		34.1	306.7	2,907.4
Wood Products	Bd.Ft. 3/		3,090.0	30.9		440.0	4.4	35.[illegible]
Other 4/				20,129.0			34,824.6	54,953.6
Total		9,342.3		304,172.1	18,640.1		474,212.[illegible]	778,348.0

1/ Current reflects average conditions during 1959-74 in Oklahoma and 196[illegible]-74 in Texas.
2/ Include crops not shown individually and not harvested cropland.
3/ Based upon $10 per thousand board feet.
4/ Includes grazing on Federal land, grazing of wheat harvested for grain, and cottonseed.
5/ Based principally on Agricultural Price Standards, U.S. Water Resources Council, October 1976.

Source: River Basin Staff, USDA

TABLE 5-20

Number of Forest Product Industry Establishments

Red River Basin Above Denison Dam

Industry	1947	1954	1963	1972	Percent Change 1947 - 1972
Lumber and Wood Products	21	32	30	38	+81 percent
Furniture and Fixtures	8	21	16	11	+38 percent
Paper and Allied Products	3	4	6	8	+167 percent
TOTAL	39	81	52	57	+46 percent

Note: The general manufacturing sector had 8,868 establishments in 1947, and increased to 17,472 by 1972, an increase of 97 percent.

Source: Bureau of Census, Census of Manufacturers.

TABLE 5-21

Total Employment and Payroll for the Forest Product Industry

Red River Basin Above Denison Dam

Industry	Basin Total Employment (Thousand)	Basin Total Payroll (Million Dollars)
Lumber and Wood Products	1.9	11.1
Furniture and Fixtures (Wood only)	0.2	1.2
Paper and Allied Products	0.6	5.0
TOTAL	2.7	17.3

Source: Bureau of the Census, Department of Commerce, 1972.

The paper and allied products industry manufactures wood pulp and converts pulp into many kinds of paper or paper board. Only eight establishments, or 12 percent of the study area's forest product industry, were in this category in 1972, an increase of 63 percent from 1947, Table 5-21. This industry produced 600 jobs with a payroll of $5 million in 1972.

New capital expenditures made during 1972 for permanent additions and major alterations to plants, as well as for new machinery and equipment purchases, totaled $2.5 million for the basin's wood-using industry, Table 5-22. The items included in this segment are those on which depreciation accounts can be maintained.

TABLE 5-22

New Capital Expenditures for Forest Product Industry

Red River Basin Above Denison Dam

Industry	New Capital Expenditures -----Million Dollars----
Lumber and Wood Products	1.5
Furniture and Fixtures (Wood only)	0.1
Paper and Allied Products	0.9
TOTAL	2.5

Source: Bureau of the Census, Department of Commerce, 1972.

PROJECTED AGRICULTURAL AND FOREST PRODUCTION

The Water Resources Council's Series E' national and State projections are used as the basis for baseline projections of agricultural output in this basin. Projections of agricultural production at the national level were derived from a product by product analysis of historical patterns of food and fiber consumption. These patterns are heavily influenced by population, per capita income and foreign trade.

Specific assumptions about these factors in the future were used to project the national demands for food and fiber.

The national projections were distributed among States by an extension of trends that occurred from 1947 to 1970. The Oklahoma and Texas State totals were then disaggregated to the part of each State in the basin on the basis of the historical percentage of each commodity to the State total. Agricultural census data was used for 1949 through 1969 and Crop Reporting Service data for 1970 through 1974. Percentages for the latter years were weighted more heavily than for the earlier years. This step-down procedure was completed for 2000 and 2020, results are shown in Table 5-23.

Since neither national economic demand nor supply has been allocated to the basin by either OBERS or the Forest Service, the "desired futures" for forest products are assumed to be the same as the "without projections" as presented in Chapter 6.

REDUCTION IN AGRICULTURAL LAND BASE

The amount of land available for agricultural production is affected by urban expansion, inundation of land by water impoundments, expansion of industrial areas, increase in road miles, etc. Agriculture is often the residual user of land, thus the amount of land that will be used by non-agricultural interest must be considered. Current and projected acres of land and water are shown in Table 5-24.

The 1970 population was used to develop a per capita requirement for urban and built-up area plus consideration for anticipated changes in road and railroad miles. This per capita requirement was then used as a base for projected per capita requirements which in turn were multiplied by population projections.

SOIL RESOURCE GROUPS

Productive qualities of agricultural soils are identified and grouped according to cropping patterns, yield characteristics, responses to fertilizers, and management. The Soil Resource Groups (SRG) were developed by the Soil Conservation Service to permit an acceptable degree of accuracy in estimating and projecting crop yields.

Soils of the Oklahoma portion of the basin were mapped and placed on a computer retrieval system designated MIADS (maps inventory and display system). Each 40 acre cell was mapped using eight inch per mile aerial photographs and letting the predominant mapping unit represent each cell.

TABLE 5-23

Baseline Agricultural Projections

Red River Basin Above Denison Dam

Item	Unit	Oklahoma			Texas		
		Current 1/	2000 2/	2020 2/	Current 1/	2000 2/	2020 2/
		(000)			(000)		
Wheat	bu	30,695.3	50,822.7	60,813.0	25,136.6	32,900.0	34,965.0
Grain Sorghum	bu	5,894.4	8,594.5	9,710.8	68,533.7	138,202.7	156,112.9
Cotton	lb/lint	136,832.9	75,815.3	71,798.6	198,849.7	169,730.8	189,436.4
Peanuts	lb	112,674.1	408,165.4	520,354.1	11,040.0	23,670.0	29,720.0
Alfalfa	ton	523.2	854.1	1,137.2	235.8	360.7	479.0
Other Hay	ton	-	-	-	380.9	586.1	778.4
Soybeans	bu	-	-	-	996.6	5,835.6	6,492.5
Barley-Oats	bu	-	-	-	4,219.5	8,323.8	10,299.9
Sugar Beets	ton	-	-	-	303.9	562.9	687.9
All Livestock	Index	100	140	160	100	160	191

1/ Current reflects 1968-1974 average conditions.

2/ Source: Water Resources Council, 1972 OBERS Projections Series E' disaggregated to state parts of the basin.

TABLE 5-24

Current and Projected Major Nonagricultural Land and Water Base

Red River Basin Above Denison Dam

Use	Oklahoma			Texas		
	Current	2000	2020	Current	2000	2020
	Acres					
Water	310,550	327,500	327,500	243,450	276,400	284,300
Land						
Federal	257,250	271,300	271,300	41,050	41,050	41,050
Urban and Built-up	552,350	625,800	709,000	295,900	391,500	492,800

Source: River Basin Staff, SCS

Current land use was mapped simultaneously with the soil units and using the same procedure. The predominant land use is, therefore, tied to the predominant soil unit of each 40 acre cell. Each soil mapping unit was placed into a SRG and was used to evaluate present and future production potentials. The quantities of each SRG and its major use are shown in Table 5-25 for Oklahoma.

In Texas soil information contained in the 1967 Conservation Needs Inventory was used to identify the acreage and land use for each SRG. Table 5-26 shows the quantities of each SRG and its major use for Texas.

PROJECTIONS RELATED TO SPECIFIC COMPONENTS

Projections related to some of the specific components in the remainder of this report are based upon population projections obtained from State agencies. Oklahoma Employment Security Commission (OESC) and Texas Water Development Board (TWDB) population projections are used in estimating the nonagricultural water, recreation, and fishing and hunting components of this report.

U. S. Department of Agriculture guidelines for cooperative river basin surveys indicate that OBERS Series E projections are ordinarily used for estimating future population and related factors. However, an alternative set of population projections may be used in lieu of OBERS Series E, if the effects on problems, needs, and changes in land and other resource use of the alternative set are compared with the needs which would result from use of the OBERS Series E projections.

The OESC, TWDB, and OBERS Series E population projections are shown in Table 5-2. The States' projections are significantly different from OBERS. In the Oklahoma portion of the basin, OESC estimates exceed OBERS by 32.5 percent in 2000 and 41.7 percent in 2020. TWDB projections are 32.5 percent greater than OBERS for 2000 and 61.9 percent higher for 2020.

Readers of this report need to be aware of differences that result from use of alternative population projections. The desired future projections shown in this chapter can be adjusted downward by the percentage differences shown above to assess the needs likely to occur with OBERS Series E population projections.

TABLE 5-25

Current Major Agricultural Land Uses

Red River Basin Above Denison Dam
(Oklahoma)

Soil Resource Group	Cropland		Pasture					
	Non-Irrigated	Irrigated	Non-Irrigated	Irrigated	Range	Forest	Total	Percent
	----------	----------	----------	000 Acres	----------	----------	----------	----------
AA	413.5	34.4	105.2	7.7	195.0	74.0	829.8	8.9
BB	41.8	5.0	11.4	1.2	30.8	5.1	95.3	1.0
CC	11.0	-	9.4	-	11.9	10.9	43.2	.5
DD	52.1	-	41.6	-	189.4	52.9	336.0	3.6
EE	248.3	14.8	13.2	3.2	35.7	5.6	320.8	3.4
FF	387.9	22.9	31.1	3.9	102.4	3.0	551.2	5.9
GG	355.6	16.8	53.3	3.8	182.6	15.3	627.4	6.7
HH	326.2	17.5	59.6	4.0	205.9	9.8	623.0	6.6
II	251.9	13.6	50.0	2.6	304.6	21.4	644.1	6.9
JJ	292.0	3.0	94.9	1.0	407.0	19.7	817.6	8.8
KK	72.2	-	16.8	-	114.5	5.3	208.8	2.2
LL	205.2	13.5	58.3	2.6	94.8	42.0	416.4	4.5
MM	101.8	6.0	97.1	2.0	208.7	114.4	530.0	5.7
NN	124.6	8.8	21.5	1.8	75.7	17.8	250.2	2.7
OO	83.3	1.0	39.3	.4	138.3	50.6	312.9	3.3
PP	195.1	-	185.6	-	955.2	236.9	1,572.8	16.8
RR	118.7	-	38.2	-	922.3	83.6	1,162.8	12.5
Total	3,281.2	157.3	926.5	34.2	4,174.8	768.3	9,342.3	100.0
Percent	35.1	1.7	9.9	.4	44.7	8.2	100.0	

Source: SCS and ERS

TABLE 5-26

Current Major Agricultural Land Uses

Red River Basin Above Denison Dam

(Texas)

Soil Resource Group	Cropland		Pasture		Range	Forest	Other	Total	Percent
	Non-Irrigated	Irrigated	Non-Irrigated	Irrigated					
	---000 Acres---								
70	1,395.3	1,040.7	23.4	33.3	1,163.6	.8	20.6	3,677.7	27.0
71	447.0	94.0	8.3	9.9	553.4	-	8.4	1,121.1	8.2
72	78.4	31.0	6.9	.9	295.6	2.7	2.6	418.1	3.1
73	204.2	16.8	29.7	2.2	289.7	55.0	9.3	607.0	4.4
74	743.1	151.3	19.8	6.6	799.5	18.6	16.6	1,755.7	12.9
75	139.0	16.7	1.9	.7	113.0	-	2.3	273.6	2.0
76	157.4	11.1	5.4	.6	530.8	-	5.8	711.0	5.2
77	314.7	7.9	46.2	-	260.6	2.7	7.1	639.3	4.7
78	111.1	2.2	20.3	-	684.8	.9	6.5	825.7	6.0
79	8.2	-	5.2	-	516.8	.1	2.1	532.4	3.9
80	47.3	.2	8.3	-	1,278.5	5.4	6.5	1,346.3	9.9
81	14.8	-	6.2	-	992.4	2.2	6.3	1,021.9	7.5
82	16.9	3.0	7.1	-	135.5	4.1	1.2	167.9	1.2
83	86.0	17.9	11.9	8.3	288.1	15.6	6.8	434.6	3.2
84	9.8	1.0	3.3	-	91.7	.1	1.9	107.7	.8
Total	3,773.3	1,393.6	204.0	62.4	7,994.2	108.3	104.2	13,604.0	100.0
Percent	27.7	10.2	1.5	.5	58.6	.8	.7	100.0	

Source: SCS and ERS

Floodwater Damage

Basin floodwater damages, mostly agricultural, are projected to increase in the future. The increase in damages is assumed to result primarily from an increase in the quantity and associated value of agricultural products produced rather than from extensive land use changes.

The total upstream flood plain area incurring damages is 1,001,900 acres, and it is assumed that this acreage will remain constant over time.

Rural floodwater damages relate directly to the management of land used for crops and pasture production and to a lesser degree to other rural land products. Both crop and pasture yields usually increase as flood hazards are minimized or eliminated.

The future desire is to reduce flood damages where it is economically feasible.

Impaired Drainage

The Texas portion of the basin contains approximately 95,500 acres needing drainage. This includes 62,000 acres of cropland, 27,300 acres of pastureland, and 6,200 acres of forest land. Approximately 50,100 acres need drainage in the Oklahoma portion.

The main cause of the drainage problem in the Texas portion is due to poor irrigation management practices and inadequate outlets.

The counties of Montague, Wichita, and Wilbarger contain the majority of the acres that would be feasible to drain.

The major drainage problem in the Oklahoma portion is associated with the Roebuck soils located in Jefferson County. There are other soils such as Asa, Claremont, Gracemont, and Miller which have a tendency to be wet, but these are not as concentrated as is the Roebuck.

Water Requirement

The water requirement is expected to increase by the year 2000 as well as 2020. The requirement for nonagricultural use which includes municipal, industrial, rural, and utility shows a sharp increase. Much of this requirement is due to the expected population increase in the basin.

The greatest requirement will be for irrigation water. Approximately 1.6 million acres are irrigated in the basin with 1.4 million acres being on the high plains of Texas. If sufficient water supplies were available, the irrigated acreage on the high plains is expected to increase to over 1.8 million acres by 2020. Over 3.0 million additional acres in Texas are suitable for irrigation. The irrigation water demands in Oklahoma are expected to double by the year 2000 and double again by 2020.

Table 5-27 shows the irrigation and nonagricultural water requirements.

Outdoor Recreation

The public desire or demand to participate in outdoor recreational activities is rapidly increasing. According to a survey by the Outdoor Recreational Resource Review Commission published in 1962, 90 percent of all Americans participated in some form of outdoor recreation in the summer of 1960. This totaled to 4.4 billion separate activity occasions. These activity occasions are expected to increase to 6.9 billion in 1976 and by the year 2000 to an estimated 12.4 billion or a threefold increase from 1960.

The desires for selected outdoor recreational activities in the basin are shown in Table 5-28.

Many of these selected recreational activities will increase between four and five times from 1970 to 2020. One recreational activity in Texas, freshwater swimming, is expected to increase as much as 15 times by 2020.

Fishing and Hunting

The public desires (demand) to utilize the fish and wildlife resources within the basin for the purpose of hunting and fishing are shown in Table 5-29. Other uses of these resources were not measured during this study.

Fishing and hunting participation will nearly triple from 1970 to 2020, with most of this increase occurring in Texas.

TABLE 5-27

Water Requirements
Desired Future Conditions

Red River Basin Above Denison Dam

Use	Oklahoma			Texas			Basin Total		
	Current	2000	2020	Current	2000	2020	Current	2000	2020
	acre-feet								
Irrigation	356,870	683,800	1,362,200	2,048,688	2,240,000	2,520,000	2,405,558	2,923,800	3,882,200
Non-Agriculture	154,327	200,898	242,946	118,091	206,788	268,700	272,418	407,686	511,646
TOTAL	511,197	884,698	1,605,146	2,166,779	2,446,788	2,788,700	2,677,976	3,331,486	4,393,846

Source: River Basin Staff, Texas Water Development Board, and Oklahoma Water Resources Board

TABLE 5-28

Selected Recreational Activity
Desired Future Conditions

Red River Basin Above Denison Dam

Activity	Unit	Oklahoma 1970	Oklahoma 2000	Oklahoma 2020	Texas 1970	Texas 2000	Texas 2020	Basin Total 1970	Basin Total 2000	Basin Total 2020
Camping	1000 Activity Days	1,555	1,861	2,021	1,954	6,828	8,423	3,509	8,689	10,444
	Sites	2,591	3,102	3,368	3,707	12,956	15,983	6,298	16,058	19,351
Picnicking	1000 Activity Days	4,715	5,119	5,434	2,313	16,249	23,828	7,028	21,368	29,262
	Sites	3,742	4,063	4,313	2,120	14,893	21,840	5,862	18,956	26,153
Swimming	1000 Activity Days	8,208	10,854	12,258	3,567	26,995	52,129	11,775	37,849	64,387
	1000 Square Yards	152	201	227	72	658	1,318	224	859	1,595
Golf	1000 Activity Days	839	1,429	1,542	614	1,655	2,654	1,453	3,084	4,196
	Holes	333	567	612	142	385	617	475	952	1,229
Outdoor Games	1000 Activity Days	4,657	5,131	5,352	1,677	5,101	8,975	6,334	10,532	14,327
	Acres	924	1,018	1,062	167	567	969	1,091	1,585	2,031
Combined Trails	1000 Activity Days	1,134	1,505	1,694	1,500	6,766	11,348	2,634	8,271	13,042
	Miles	168	223	251	268	1,210	2,030	436	1,433	2,281
Horseback Trails	1000 Activity Days	1,779	2,369	2,673	464	2,677	4,547	2,243	5,046	7,220
	Miles	527	702	792	23	133	226	550	835	1,018
Watersports	1000 Activity Days	10,723	14,546	16,457	5,385	31,825	43,393	16,108	46,371	59,850
	Surface Acres	32,010	43,422	49,126	16,149	69,224	109,856	48,159	112,646	159,982

Source Compiled by SCS from Oklahoma's State Comprehensive Outdoor Recreation Plan, (SCORP) and Texas Outdoor Recreation Plan (TORP)

TABLE 5-29

Fishing and Hunting
Desired Future Conditions

Red River Basin Above Denison Dam

State	Fishing 1970	Fishing 2000	Fishing 2020	Hunting 1970	Hunting 2000	Hunting 2020
	---------------1000 activity days------------------					
Oklahoma	2733	3254	3685	756	885	995
Texas	5498	13706	20232	944	2558	3904
Basin Total	8231	16963	23917	1700	3443	4899

Source: Fish and Wildlife Resource Special Reports - SCS

Erosion and Sedimentation

The amounts of erosion that will occur under desired future conditions are shown in Table 5-30. The desired future is based on the desire of the inhabitants of the basin to live in an environment which is as free as possible from environmental and economic detriments. This desire has been expressed in the past in the high rate of application of measures to reduce erosion and sedimentation. Most of the basin shows a high degree of protection to the land base, and it is, therefore, reasonable to project a continuance of this trend into the future. The projections of the desired future conditions assume no restrictions on monetary or technical assistance to the landowners and operators within the basin.

Another assumption is that the desired future condition for sheet erosion would be to reduce sheet erosion rates to the allowable tolerance (T factor) for the soil wherever the value has not been reached.

One factor to be evaluated is that of determining the amount of sediment to be delivered to Lake Texoma under desired future conditions, Table 5-31. Since the loss of land to gully, streambank or shoreline erosion is environmentally and economically undesirable, it is assumed that the desired future condition would include almost entire elimination of these damages. The same assumption is also made in regard to roadside erosion, flood plain scour damages, and overbank deposition on the flood plain.

TABLE 5-30

Gross Erosion from all Sources
Desired Future Conditions

Red River Basin Above Denison Dam

Source	Oklahoma		Texas		Basin Total	
	2000	2020	2000	2020	2000	2020
	tons per year					
Sheet						
Cropland						
(Dry)	17,959,700	14,367,700	21,151,600	16,006,800	39,111,300	30,374,500
(Irrigated)	1,395,200	1,116,200	710,000	310,000	2,105,200	1,426,200
Pastureland	1,268,400	1,014,700	160,900	152,900	1,429,300	1,167,600
Rangeland	8,473,600	6,778,900	16,701,200	15,499,100	25,174,800	22,278,000
Forest Land (Grazed)	1,333,500	1,066,800	-	-	1,333,500	1,066,800
Other Land	-	-	49,500	46,600	49,500	46,600
Sub-total Sheet Erosion	30,430,400	24,344,300	38,773,200	32,015,400	69,203,600	56,359,700
Gully	1,086,900	652,100	3,520,400	2,346,900	4,607,300	2,999,000
Streambank	686,600	412,000	2,215,200	1,476,800	2,901,800	1,888,800
Roadside	596,400	357,800	1,074,300	716,200	1,670,700	1,074,000
Flood Plain Scour	1,406,300	703,100	841,500	561,000	2,247,800	1,264,100
GRAND TOTAL	34,206,600	26,469,300	46,424,600	37,116,300	80,631,200	63,585,600

Source: SCS and FS

TABLE 5-31

Acres Lost and Damaged by Erosion and Sediment Delivered
Desired Future Conditions

Red River Basin Above Denison Dam

Item	Oklahoma		Texas		Basin Total	
	2000	2020	2000	2020	2000	2020
Sediment Delivered by Source 1/	---------------	---------------	tons per year	---------------	---------------	---------------
Sheet erosion 2/	5,828,600	4,662,900	8,597,200	7,321,000	14,425,800	11,983,900
Gully erosion	308,900	185,300	3,168,300	2,112,200	3,477,200	2,297,500
Streambank erosion	274,700	164,800	1,993,700	1,329,100	2,268,400	1,493,900
Roadside erosion	149,100	89,400	966,900	644,600	1,116,000	734,000
Flood Plain Scour	246,100	147,700	737,400	504,900	983,500	652,600
Land Lost by Source	---------------	---------------	acres per year	---------------	---------------	---------------
Gully erosion	22	13	134	90	156	104
Streambank erosion	17	10	104	69	121	79
Land Damage by Source	---------------	---------------	acres per year	---------------	---------------	---------------
Scour	31,900	15,900	40,600	27,600	72,500	42,900
Wind	175,000	116,700	303,700	202,500	478,700	319,200
Overbank deposition	57,900	29,000	102,300	68,200	160,200	97,200
	---------------	---------------	tons per year	---------------	---------------	---------------
Sediment Delivered to Lake Texoma (tons/yr.)	6,340,000	4,981,400	6,354,800	4,895,200	12,694,800	9,876,600

1/ Delivered to mouths of watersheds

2/ Includes forest land

Source: SCS and FS

Land Treatment

The projected increases for the 50 year period 1970 - 2020 is based upon the desires that 80 percent of the land be adequately treated. Oklahoma can meet this goal with present on-going programs. In order for Texas to meet this goal, it is assumed that an 80 percent level of Federal cost-sharing will supply the monetary incentive necessary for this goal to be attained. It must be recognized that a greater number of technical personnel would be necessary to achieve this level of installation of conservation measures.

It is desired that 68 percent of the land in Texas will be adequately treated by 2000 and 80 percent by 2020, Table 5-32.

Archeological and Historical Sites

In recent years there has been a surge of interest in archeological sites. This was partly due to the National Environmental Policy Act of 1969. Archeological, historical, or other special expertise needed must be solicited from appropriate agencies and groups. A more careful study of the environmental impact a potential project will have is now being made before construction begins. The closer investigations have resulted in an increasing number of archeological sites being discovered.

At present there are approximately 3,000 archeological sites and 128 historical sites recognized in the basin. This number is expected to increase to 3,020 sites by the year 2000 and 3,050 by 2020. The present estimate of 128 historical sites is expected to increase to 132 by the year 2000 and 135 by 2020.

TABLE 5-32

Land Treatment
Desired Future Conditions

Red River Basin Above Denison Dam
(Texas)

Item	Cropland		Pastureland	Rangeland	Other Agr. Land	Total Agr. Land
	Dry	Irrigated				
1975						
Total Acres (1000)	3,773	1,394	266	7,994	104	13,531
Adeq. Treated 1/ (1000 acres)	1,779	406	81	3,118	63	5,447
Adeq. Treated (percent)	47	29	30	39	60	40
2000						
Total Acres (1000)	4,263	906	264	7,899	104	13,436
Adeq. Treated 1/ (1000 acres)	2,984	703	136	5,230	83	9,136
Adeq. Treated (percent)	70	78	51	67	80	68
2020						
Total Acres (1000)	3,432	1,735	266	7,797	104	13,335
Adeq. Treated 1/ (1000 acres)	3,089	1,220	159	6,107	94	10,668
Adeq. Treated (percent)	90	70	59	78	90	80

1/ Land adequately treated is a combination of conservation practices and a desired level of management to protect and improve soil, water, and plant resources.

Source: SCS

PROJECTED RESOURCE USE AND PRODUCTION WITHOUT ACCELERATED DEVELOPMENT

RED RIVER BASIN ABOVE DENISON DAM

CHAPTER 6

PROJECTED RESOURCE USE AND PRODUCTION WITHOUT ACCELERATED DEVELOPMENT

INTRODUCTION

The study of future water and related land uses requires definition of significant economic and environmental conditions which lend consistency and comparability to the data used.

Beginning with conditions as they exist at present, two projections of future conditions without and with accelerated resource development provide the basis for evaluation of beneficial and adverse effects that may accrue as a result of the development. These projections are simply estimates of future conditions under carefully defined circumstances. A before and after comparison based on a status quo would not be helpful for analytical purposes because the problem and need elements are expected to change even without acceleration. The basis of projected conditions is to evaluate the implications of certain trends and under stated assumptions extend those trends into the future. This chapter describes expected future basin conditions without accelerated resource development.

ASSUMPTIONS CONDITIONING PROJECTED DATA

Projected conditions are based on long-run or secular trends and ignore cyclical fluctuations which characterize the short-run path of our economy. General assumptions that underlie the projections are:

1. Projections include anticipated development wherever the planners were assured that development would occur; assurances are based on implementation, authorizations such as existing and on-going programs, funded projects, projects under construction, and operational projects as of December 31, 1976.

2. Nearly all of the water used for irrigation comes from ground water sources. In some parts of the basin this source is gradually being depleted due to the lack of adequate natural recharge.

Without accelerated resource development, the projected irrigated acreage is held constant for 2000 and 2020 in Oklahoma. Under the same condition, the irrigated acreage in Texas is projected to decline from about 1.5 million acres to less than one million in 2000 and further decline to less than half a million in 2020. Most of the decline will occur in the high plains area which depends upon the Ogallala Aquifer for water.

3. The economy will become more efficient in satisfying human needs and wants. Specifically, agricultural technology and management will continue to improve.

4. Resources are assumed known and limited in quantity.

5. Socio-industrial land uses including urban centers, towns, transportation routes, industrial tracts, rights-of-way, etc. continue to be priority uses of land resources without legislation to constrain it.

THE USDA ANALYSIS OF FUTURE CONDITIONS

A vital portion of the planning process is making projections of selected elements that are affected by the implementation or lack of implementing resource development plans. If present trends in the use of agricultural resources continue (plus allowance for the recent estimates as to the availability of ground water for irrigation) and no further resource developments come about one can estimate the amount of agricultural production for 2000 and 2020 for the "without" situation. These projections can then be compared with other projections to determine if added or accelerated water and related land resource development is a requisite to alleviating differences between projections.

A least-cost linear programming model was used to facilitate combining the many variables that are a part of crop production. In Chapter 5, soil resource groups (SRG) were defined for each States' portion as well as the acres of each by major land use.

Major land use shifts between range or pasture to cropland, forest to cropland, etc. were constrained to prevent unrealistic changes in resource use. Crops were allowed to shift within specified limits between soil resource groups and geographic areas wherever they held a competitive advantage given all other crop combinations.

Productivity per acre varies between soil resouce groups and geographic areas as well as over time. Current crop yields

were used as a base for projections to 2000 and 2020. These changes, in Texas, are based on trends developed by specialists for the Water Resources Institute at Texas A&M University.

In Oklahoma a curvilinear Spillman type function was used to relate the historical State Crop Reporting Service yield data to the future.

Cost of production budgets were prepared for each of the crops, both irrigated and nonirrigated. The budgets reflect information obtained from secondary sources which were representative of 1974.

Fixed and variable per acre charges for materials, labor, machinery, and capital which are independent of crop yield were first determined. When tillage methods varied between soil resource groups this was considered. Fertilizer inputs also were varied between SRG's and time periods. Harvest costs were generally based upon the per unit of output or yield per acre.

The acreage of cropland pasture reflects the amount of wheat that is harvested by grazing plus other annual grazing species. "Not harvested cropland" includes cropland that is held for moisture conserving practices (skip-row, wheat-fallow, etc.), as well as crops lost to weather.

Agricultural Production

The projected agricultural production, without accelerated resource development, for 2000 and 2020 is shown in Table 6-1. The value of production for the basin is expected to increase from $778.4 million currently to $885.0 million by 2000 and $894.1 million by 2020.

The ground water decline in the high plains area in Texas was largely responsible for constraining further increases in the value of agricultural production. Currently the value of production from irrigated cropland in the Texas part exceeds $262 million annually. By 2020, this measure is expected to decline to $118.5 million. Also by 2020 the value of production from nonirrigated crops will exceed the value from irrigated cropland.

In Oklahoma the value of production increases from $304.2 million currently to $376.9 million by 2000 and $407.9 million by 2020. This overall increase occurs in both irrigated and nonirrigated categories.

TABLE 6-1

Projected Value of Agricultural Production
Future Without Accelerated Development

Red River Basin Above Denison Dam

Land Use	Production Unit	2000 Oklahoma Acres	Oklahoma Production (unit)	Oklahoma Value ($)	Texas Acres	Texas Production (unit)	Texas Value ($)	Total Basin Value 4/ $
		(000)						
Cropland		3,468.0	-	292,333.1	5,169.4	-	444,030.6	736,363.7
Nonirrigated		3,310.6	-	248,361.0	4,314.4	-	212,288.9	461,150.0
Wheat	bu	1,566.9	42,958.2	138,370.1	1,071.7	23,314.6	73,110.9	211,981.0
Grain Sorghum	bu	112.5	5,487.5	13,027.3	506.5	18,868.3	43,849.3	56,877.1
Cotton	lb/lint	176.3	56,128.4	21,890.1	344.7	108,[illegible]29.7	43,371.9	65,262.0
Peanuts	lb	69.1	170,783.1	30,399.4	2.7	3,717.0	650.5	31,050.0
Alfalfa	ton	199.0	604.0	33,221.5	39.3	141.2	7,764.8	40,986.3
Other Hay	ton	-	-	-	161.1	488.3	21,483.4	21,483.4
Barley-Oats	bu	-	-	-	73.7	4,797.4	8,011.6	8,011.6
Crop Pasture	AUM	635.0	1,272.5	11,452.5	756.6	1,560.7	14,046.0	25,498.7
Other 1/		551.3	-	-	1,358.3	-	-	-
Irrigated		157.4	-	43,472.1	855.0	-	231,741.7	275,213.7
Wheat	bu	13.2	750.5	2,446.6	48.9	2,245.3	6,893.2	9,339.8
Grain Sorghum	bu	12.0	910.5	2,161.6	515.[illegible]	67,137.7	156,028.0	158,189.6
Cotton	lb/lint	35.8	19,686.9	7,677.9	101.9	61,300.8	24,520.3	32,198.2
Peanuts	lb	29.7	115,970.0	20,642.7	[illegible]	19,952.5	3,491.7	24,134.3
Alfalfa	ton	31.7	191.7	10,543.3	[illegible]	149.5	8,223.7	18,767.0
Other Hay	ton	-	-	-	[illegible]	22.4	983.9	983.9
Barley-Oats	bu	-	-	-	4.4	447.7	747.7	747.7
Soybeans	bu	-	-	-	46.8	1,694.9	8,389.7	8,389.7
Silage	ton	-	-	-	7.3	203.6	3,257.2	3,257.2
Sugar Beets	ton	-	-	-	19.6	562.8	16,737.7	16,737.7
Crop Pasture	AUM	-	-	-	33.3	274.3	2,468.5	2,468.5
Other 1/		30.0	-	-	40.8	-	-	-
Pasture	AUM	1,124.9	5,329.9	47,387.6	263.6	866.0	7,794.3	55,181.9
Nonirrigated	AUM	1,090.8	5,011.9	45,107.0	247.2	727.8	6,550.3	51,657.3
Irrigated	AUM	34.1	309.0	2,780.6	16.4	138.2	1,244.0	4,024.6
Range	AUM	3,914.2	1,889.4	17,004.9	7,398.9	3,804.0	34,236.1	51,241.0
Forest		723.2	-	2,505.7	108.3	-	315.5	2,821.2
Grazing	AUM	-	271.9	2,447.5	-	34.1	306.7	2,754.2
Wood Products	Bd.Ft. 2/	-	2,908.7	58.2	-	440.0	8.8	67.0
Other 3/		-	-	17,208.9	-	-	21,676.4	38,885.4
Total		9,230.5	-	376,940.2	13,5[illegible].1	-	508,053.0	884,993.1

TABLE 6-1 (continued)

Projected Value of Agricultural Production
Future Without Accelerated Development

Red River Basin Above Denison Dam

		2020						
		Oklahoma			Texas			Total Basin
Land Use	Production Unit	Acres	Production (unit)	Value ($)	Acres	Production (unit)	Value ($)	Value 4/ ($)
		--(000)--						
Cropland		3,464.7	-	320,458.2	5,169.4	-	420,810.9	741,269.1
Nonirrigated		3,307.2	-	275,105.6	4,761.4	-	302,278.5	577,384.0
Wheat	bu	1,591.7	46,585.6	151,869.2	763.7	26,461.5	81,236.7	233,105.9
Grain Sorghum	bu	94.4	5,299.3	12,580.6	1,222.0	48,251.9	112,137.5	124,718.1
Cotton	lb/lint	157.3	52,123.6	20,328.2	446.4	156,522.1	62,608.8	82,937.0
Peanuts	lb	77.8	216,958.5	38,618.6	2.8	4,262.2	745.9	39,364.5
Alfalfa	ton	214.9	717.9	39,486.9	30.3	109.5	6,022.7	45,509.6
Other Hay	ton	-	-	-	114.6	395.7	17,411.3	17,411.3
Barley-Oats	bu	-	-	-	-	55.8	4,004.8	6,688.1
Crop Pasture	AUM	629.7	1,358.0	12,222.1	-	767.9	1,714.2	15,427.5
Other 1/		541.4	-	-	1,357.8	-	-	-
Irrigated		157.4	-	45,352.7	408.0	-	118,532.4	163,885.1
Wheat	bu	19.8	878.8	2,864.9	11.1	484.3	1,486.8	4,351.7
Grain Sorghum	bu	14.1	1,223.9	2,905.5	226.7	27,724.8	64,432.3	67,337.8
Cotton	lb/lint	33.1	19,675.0	7,673.2	48.5	32,914.0	13,165.6	20,838.8
Peanuts	lb	26.0	110,510.6	19,670.9	6.9	22,812.2	3,992.1	23,662.9
Alfalfa	ton	34.3	222.5	12,238.2	20.4	140.5	7,725.2	19,963.4
Other Hay	ton	-	-	-	2.0	10.6	464.2	464.2
Barley-Oats	bu	-	-	-	1.0	109.1	182.2	182.2
Soybeans	bu	-	-	-	24.6	957.5	4,739.4	4,739.4
Silage	ton	-	-	-	3.0	83.7	1,339.2	1,339.2
Sugar Beets	ton	-	-	-	21.6	687.9	20,458.1	20,458.1
Crop Pasture	AUM	-	-	-	9.8	60.8	547.1	547.1
Other 1/		30.0	-	-	32.3	-	-	-
Pasture	AUM	1,145.1	5,696.6	51,269.6	263.6	940.3	8,462.8	59,732.4
Nonirrigated	AUM	1,111.0	5,373.5	48,361.7	247.2	789.4	7,104.5	55,466.2
Irrigated	AUM	34.1	323.1	2,907.9	16.4	150.9	1,358.3	4,266.2
Range	AUM	3,838.6	1,848.7	16,638.4	7,797.3	4,024.3	36,218.9	52,857.3
Forest		707.2	-	2,450.5	108.3	-	317.4	2,767.9
Grazing	AUM	-	265.9	2,393.2	-	34.1	306.7	2,669.9
Wood Products	Bd.Ft. 2/	-	2,865.3	57.3	-	533.8	10.7	68.0
Other 3/		-	-	17,064.1	-	-	20,441.6	37,505.7
Total		9,155.6	-	407,880.9	13,442.9	-	486,251.6	894,132.5

1/ Includes crops not shown individually and not harvested cropland.
2/ Based upon $20 per thousand board feet.
3/ Includes grazing on Federal land, grazing on wheat harvested for grain and cottonseed.
4/ Based principally on Agricultural Price Standards, U. S. Water Resources Council, October 1976.

Source: River Basin Staff - USDA

OBERS projections show wheat and grain sorghum to remain as the two major crops through 2020. Cotton production is projected to decline rapidly by 2000 and increase slightly by 2020. Sizeable increases are expected in peanut and sugar beat production. These production levels were not allowed to exceed OBERS E' production levels.

In Oklahoma an alternative set of baseline agricultural projections was also made. These projections were based on historical acres used for different crop species, average yield per acre for each crop species and the projected cropping mix. It should be noted that these projections of production compare favorably with OBERS for wheat and alfalfa. Major differences exist between peanuts, cotton, and grain sorghum. These alternative projections show peanuts increasing 76 percent by 2020, cotton declining only four percent by 2020, and grain sorghum declining by 17 percent by 2020. OBERS shows peanuts increasing 4.6 times by 2020, cotton declining 48 percent and grain sorghum increasing 65 percent by 2020. For the purpose of determining needs OBERS E' was used. However, it is felt these differences should be pointed out.

The increased grazing from pastureland comes from Oklahoma. This increase is due to increased yields and a net increase in acres. The increased production from rangeland occurs in Texas.

Forest Production

If, as expected, the recent cut-growth ratios remain the same, then forest production will show a slight increase because the total growing stock volumes will increase just as the capital grows at a fixed rate of compound interest.

The current and projected forest production in the basin is shown in Table 6-1.

The slight decline in forest acreage should have little effect on the basin's relatively unimportant wood-using industry. This acreage loss, concentrated largely in the post oak-blackjack oak forest type, will be more than offset by the normal increase in production. (Since no increase in demand for forest products is projected, there is no need to improve management or increase production.)

In the event future demands do exceed forecasts the SKY-LAB inventory and special report should be expanded into a more detailed forest survey. Such an assessment should provide the information from which decisions could be made to exploit the forest resources with the least environmental impact.

EXISTING PROJECTS AND PROGRAMS

The future without plan conditions reflects the basin's future based on the continuation of present programs but at uncertain rates. Some programs change from year to year while others remain constant or are cancelled.

Flooding

Projections of floodwater damages were made for the upstream watersheds. Existing programs to reduce flooding include the Flood Control Act of 1944 (PL 78-534), the Watershed Protection and Flood Prevention Act (PL 83-566), the Great Plains Conservation Program (PL 84-1021), and the Resouce Conservation and Development Program under the authorization of the Food and Agriculture Act of 1962 (PL 87-703) and the Soil Conservation Act of 1935 (16 USC - 590 a-f). The watershed project, GPCP contracts, and the RC&D project measures that are planned and approved for operations were assumed to be completed by 1977.

Land Treatment

Projections of land treatment needs were made. These needs include measures to reduce erosion, excess water, sediment, and to prevent deterioration of the agricultural land base.

Available programs for land treatment include watershed projects under PL 83-566 and PL 78-534, GPCP under PL 84-1021, and RC&D project measures under the Soil Conservation Act of 1935 and the Food and Agriculture Act of 1962. These projects include critical area treatment as well as other conservation measures.

Other land treatment programs provide technical assistance and/or financial assistance. These programs include Soil Conservation Service Establishing Act (PL 74-46), Agricultural Stabilization and Conservation Service assistance, Extension Service assistance, and U. S. Forest Service programs, among others.

Erosion and Sedimentation

The reduction of erosion and sedimentation will be the result of installation of flood damage reduction and land treatment measure programs.

Recreation

Recreation facilities identified include those presently existing. The RC&D program and the watershed program, among others, provide some means to meet recreation demands.

Fishing and Hunting

Existing resources are inadequate to meet projected demands. Programs are available that will improve hunting and fishing opportunities.

Archeological and Historical Sites

Projections for archeological and historical sites to be preserved assumed that existing State and local programs would accomplish these tasks with some Federal aid. The Texas Historical Commission and Oklahoma Archeological Commission, within their limited authority, would provide for the preservation or protection of identified sites.

Water Supply

Existing programs available include the Watershed Protection and Flood Prevention Act (PL 83-566), (PL 78-534), and the Resource Conservation Development Program. Some proposed watershed projects have plans for storage of irrigation and municipal supplies. The Farmers Home Administration (FmHA) provides financial assistance to the rural sector. Rural community water systems are closely related to water and related land resource development.

SPECIFIC DESCRIPTION OF FUTURE WITHOUT PLAN CONDITIONS

Flooding

There are 1,001,900 acres in the basin (385,000 in Oklahoma and 617,000 in Texas) that are subject to flood water and associated damages and have no structural protection other than land treatment measures, Table 6-2. The current estimated average annual losses associated with these acres are $14,141,000. It is anticipated that the number of acres affected by flood waters will remain constant over time;however, monetary losses are projected to increase to $15,588,000 by the year 2000 and to $17,000,000 by the year 2020. These projected increases will result from the increase in quantity and associated value increase of agricultural products produced on these acres.

Impaired Drainage

The majority of the impaired drainage in Texas is associated with improper irrigation water management, wetness, high water table, and overflow. The present acreage needing drainage is 95,500. This is expected to decline to 87,800 acres by the year 2000 and 85,000 acres by the year 2020.

TABLE 6-2

Upstream Flooding Damage
Future Without Accelerated Development

Red River Basin Above Oenison Dam

		Oklahoma			Texas			Basin Total		
		1975	2000	2020	1975	2000	2020	1975	2000	2020
Flood plain protected by authorized projects	Ac	458,000	458,000	458,000	41,800	41,800	41,800	499,800	499,800	499,800
Annual damages remaining	$	3,485,000	3,857,900	4,270,700	900,600	1,000,700	1,111,900	4,385,600	4,858,600	5,382,600
Flood plain unprotected	Ac	384,900	384,900	384,900	617,000	617,000	617,000	1,001,900	1,001,900	1,001,900
Annual damages	$	12,419,300	13,768,700	15,241,900	1,721,600	1,819,400	1,736,700	14,140,900	15,588,100	16,978,600
Total Flood Plain	Ac	842,900	842,900	842,900	658,800	658,800	658,000	1,501,700	1,501,700	1,501,700
Total Damages	$	15,904,300	17,626,600	19,512,600	2,622,200	2,820,100	2,848,600	18,526,500	20,146,700	22,361,200

Source: SCS

Approximately 50,100 acres in the Oklahoma portion is in need of drainage. This acreage is expected to remain constant to 2020.

The drainage needs can be accomplished by the use of farm laterals, surface drainage ditches, sub-surface drainage systems, and main outlets. These drainage practices can be installed through PL-566 or RC&D channel work and associated conservation treatment.

On-going programs for installing some of the plan elements on a cost-sharing basis are available through the Agricultural Stabilization and Conservation Service. Assistance is available for individual farmers to install surface drainage ditches, as well as group projects, for installation of main outlets or lateral ditches.

The Public Law 46 program of the Soil Conservation Service provides technical assistance through local soil and water conservation districts for planning and installation of drainage systems. Assistance can be accelerated in feasible watersheds planned under PL-566 and areas covered by RC&D projects. A certain amount of drainage treatment will be done by individual farmers at their own cost without any assistance.

Water Supply

The future developed supply of water for nonagricultural and irrigation use is shown in Table 6-3. This supply is from both ground and surface water.

The Mackenzie Reservoir, located on Tule Creek in Texas, Briscoe County, is owned by the Mackenzie Municipal Water Authority. This reservoir has been completed and will furnish municipal water to several cities.

Three of the major reservoirs in Oklahoma which have potential for development by the year 2020 are Cookietown, Courtney, and Purdy. The Purdy and Cookietown reservoirs would serve municipal, flood, recreation, and fish and wildlife purposes. The water quality should meet U. S. Public Health Standards for municipal use in the Cookietown Reservoir. The Courtney Reservoir would serve irrigation, recreation, and fish and wildlife purposes. Purdy's water would not be suitable for municipal, but would meet requirements for irrigation water. These three reservoirs would control 1,322 square miles of drainage area and provide yields of 100,000 acre-feet per year for municipal and irrigation purposes. The conservation storage would contain 595,000 acre-feet and inundate 29,860 acres. The combined flood storage would be 82,000 acre-feet. These three reservoirs were not assumed in place for the future without condition.

TABLE 6-3

Water Supply
Future Without Accelerated Development

Red River Basin Above Denison Dam

Use	Oklahoma			Texas			Basin Total		
	Current	2000	2020	Current	2000	2020	Current	2000	2020
	Acre Ft/Yr								
Irrigation	208,300	208,300	208,300	2,048,700	957,000	577,200	2,259,000	1,165,300	785,500
Non-agricultural	153,500	187,100	213,900	118,100	206,800	268,700	271,600	393,900	482,600
	361,800	395,400	422,200	2,166,800	1,163,800	845,900	2,528,600	1,559,200	1,268,100

Source: Texas Water Development Board, Oklahoma Water Resources Board.

Outdoor Recreation

The existing and projected facilities for each selected outdoor recreational activity and the activity days supplied by these facilities are shown in Table 6-4.

The data for 1970 was developed from information in the State's Outdoor Recreation Plan. Oklahoma expects its facilities to remain constant throughout the study period, whereas Texas projected its for 2000 and 2020 from past historical trends since this data was available. The projected surface acres of water suitable for the water sports activities in Texas was taken from data furnished by the Texas Water Development Board.

Fish and Wildlife Resources

In general, fish and wildlife resources will increase or decrease as habitat is created or reduced. Present trends in habitat availability are expected to continue in a similar fashion through 2020.

Fisheries: The stream fisheries resource is expected to continue declining as quality and quantity of stream habitat declines. Natural and manmade pollution and growing demands for industrial, municipal, and agricultural water, either directly from the stream or through impoundment of stream water, will continue to reduce stream quality and quantity.

Construction of impoundments will continue in the future, resulting in increased lake fisheries habitat; however, the number of impoundments constructed each year should decrease as the most feasible are developed. Growing interest in catfish farming and commercial minnow ponds, in addition to greater per capita leisure time, will bolster creation and management of lake fisheries habitat.

Wildlife: Wildlife resources are expected to decline through 2020 as intensification of agricultural lands and urban sprawl reduces habitat.

As the population increases and the amount of leisure time per capita increases, greater stress will be put on public and private recreation lands, and the overall quality of habitat will be reduced. The increased interest in utilization of wildlife resources; however, will make intensive habitat management, specifically of popular game species, more profitable to private landowners. This could offset habitat loss or even increase available habitat of these game species and nongame species sharing that habitat.

TABLE 6-4

Selected Recreational Activity
Future Without Accelerated Development

Red River Basin Above Denison Dam

Activity	Units	Oklahoma 1970	Oklahoma 2000	Oklahoma 2020	Texas 1970	Texas 2000	Texas 2020	Total 1970	Total 2000	Total 2020
Camping	1000 Activity Days	875	875	875	888	1154	1421	1763	2029	2296
	Sites	1458	1458	1458	1684	2189	2694	3142	3647	4152
Picnicking	1000 Activity Days	4550	4550	4550	1457	2040	2477	6007	6590	7027
	Sites	3611	3611	3611	1335	1869	2270	4946	5480	5881
Swimming	1000 Activity Days	1426	1426	1426	2691	4400	5841	4117	5826	7267
	1000 sq yds	26.4	26.4	26.4	52.7	87	116	79.1	113.4	142.4
Golf	1000 Activity Days	1293	1293	1293	852	1448	1789	2145	2741	3082
	Holes	513	513	513	198	337	416	711	850	929
Outdoor Games	1000 Activity Days	3740	3740	3740	5159	7114	8870	8899	10854	12610
	Acres	742	742	742	944	1389	1754	1686	2131	2496
Combined Trails	1000 Activity Days	392	392	392	246	541	689	638	933	1081
	Miles	58	58	58	44	97	123	102	155	181
Horseback Trails	1000 Activity Days	138	138	138	583	1280	1691	721	1418	1829
	Miles	41	41	41	29	64	84	70	105	125
Water-Sports	1000 Activity Days	21909	21909	21909	33314	39589	39589	55223	61498	61498
	Surface Acres	65400	65400	65400	88614	100219	100219	154014	165619	165619

Source: Compiled by SCS from SCORP and TORP

Future trends in the protection of rare and endangered species are difficult to assess. The increasing public awareness of the status of threatened and endangered species is favorable to all of these species in general. Although habitat protection and management may cause increases in populations of some species, lack of information on habitat requirements and population trends of other species will not allow them adequate protection from further reduction or extinction.

Funds for research, management, and acquisition are sorely needed for the majority of wildlife species and no significant funding increases are foreseen.

An inventory of the activity days provided by the fish and wildlife resources which are accessible to the sportsman is shown in Table 6-5. This accessible supply is considered to be that portion of the existing supply (Chapter 4) which is accessible to the sportsman. In most instances the accessible supply represents approximately 25 percent of the existing supply.

TABLE 6-5

Fishing and Hunting
Future Without Accelerated Development

Red River Basin Above Denison Dam

Activity/Year	Oklahoma	Texas	Basin Total
	--------------Activity Days 000-------------		
Fishing			
1970	8150	4468	12618
2000	8850	4960	13810
2020	8850	5268	14118
Hunting			
1970	418	397	815
2000	418	397	815
2020	418	397	815

Source: SCS

Erosion and Sedimentation

The erosion rates under present conditions were applied to the projected future without project development land use. The effect of existing programs was estimated for the future and taken into account in the calculations for all categories of erosion and sedimentation. Table 6-6 shows the total amounts of gross erosion and sedimentation expected. Table 6-7 shows anticipated amounts of sedimentation, land loss, and other erosion categories.

Forest Erosion

The average soil loss rate should remain within established tolerances for on-site erosion damage or fertility loss. Included in this average situation are many small, local eroding areas and erosion hazards. The problem will require periodic monitoring and attention to keep the situation within bounds. If the problem does become significant then programs already provided by the Texas Forest Service and the Oklahoma Forestry Commission through several water-related cooperative Federal programs should be extended to do the job.

Land Treatment

The projected land treatment for the without plan conditions is shown in Table 6-8.

In Oklahoma, only those watersheds having no planned project measures are included. The adequately treated acres for PL-534 and PL-566 watersheds are assumed to be 80 percent complete by 2000. Land treatment measures for the remaining non-project acres were based on planned and applied practices. Currently, 62 percent of the land is adequately treated and it is estimated that this will be about 71 percent by 2000 and 81 percent by 2020.

With the potential soil and water conservation districts involvement in the preparation and implementation related to non-point pollution sources pursuant to Section 208 of the Federal Water Pollution Control Act Amendment of 1972 (PL 92-500), Oklahoma will be able to reach 80 percent adequately treated land by 2020.

In Texas, projected land treatment was based upon the approximate rate of accomplishment over the past 30 year period from 1940-1970. Estimates of Soil Conservation Service personnel generally served to confirm these projections. Also Federal cost-sharing is projected to be 50 percent of the cost of applying essential practices necessary to adequately treat the land. The assumption is also made that technical assistance will be available.

TABLE 6-6

Gross Erosion by all Sources
Future Without Accelerated Development

Red River Basin Above Denison Dam

Source	Oklahoma		Texas		Basin Total	
	2000	2020	2000	2020	2000	2020
	Tons Per Year					
Sheet						
Cropland						
Dry	20,275,600	19,763,500	22,468,300	24,796,200	42,743,900	44,559,700
Irrigated	1,255,600	1,283,900	738,800	352,600	1,964,400	1,636,500
Pastureland	1,687,900	1,680,500	168,900	168,900	1,856,800	1,849,400
Rangeland	9,908,100	9,494,800	17,529,800	17,305,100	27,437,900	26,799,900
Forest Land (grazed)	1,174,400	1,125,400	175,000	175,000	1,349,400	1,300,400
Other Land	-	-	52,000	52,000	52,000	52,000
Sub-Total Sheet Erosion	34,271,600	33,348,100	41,132,800	42,849,800	75,404,400	76,197,900
Gully	3,695,300	3,564,900	4,500,400	4,250,200	8,195,700	7,815,100
Streambank	2,471,800	2,416,800	2,900,600	2,850,600	5,372,400	5,267,400
Roadside	2,027,600	1,956,100	1,230,700	1,130,200	3,258,300	3,086,300
Flood Plain Scour	2,531,300	2,390,600	1,100,000	1,080,000	3,631,300	3,470,600
GRAND TOTAL	44,997,600	43,676,500	50,864,500	52,160,800	95,862,100	95,837,300

Source: SCS and FS

TABLE 6-7

Acres Lost and Damaged by Erosion and Sediment Delivered
Future Without Accelerated Development

Red River Basin Above Denison Dam

Item	Oklahoma		Texas		Basin Total	
	2000	2020	2000	2020	2000	2020
	tons/yr					
Sediment Delivered by Source 1/						
Sheet erosion 2/	6,605,800	6,372,600	9,073,100	9,453,400	15,678,900	15,826,000
Gully erosion	1,050,300	900,900	4,050,400	3,825,200	5,100,700	4,726,100
Streambank erosion	988,700	966,800	2,610,500	2,565,500	3,599,200	3,532,300
Roadside erosion	506,900	489,000	1,107,600	1,017,200	1,614,500	1,506,200
Flood Plain Scour	886,000	866,300	990,000	972,000	1,876,000	1,838,300
	acres/yr					
Land Lost by Source						
Gully erosion	73	71	172	162	245	233
Streambank erosion	56	54	136	133	192	187
	acres/yr					
Land Damaged by Source						
Scour	58,100	56,900	53,000	52,100	111,100	109,000
Wind	210,400	205,400	384,700	364,400	595,100	569,800
Overbank deposition	98,500	95,000	129,600	122,800	228,100	217,800
	tons/yr					
Sediment Delivered to Lake Texoma	7,698,600	7,426,900	7,555,900	7,749,100	15,254,500	15,176,000

1/ Delivered to mouth of watersheds
2/ Includes Forest Land

Source: SCS and FS

TABLE 6-8

Land Treatment
Future Without Accelerated Development

Red River Basin Above Denison Dam

Item	Oklahoma Cropland Dry	Oklahoma Cropland Irrigated 1/	Oklahoma Pasture Land	Oklahoma Range Land	Oklahoma Other Land 2/	Oklahoma Total	Texas Cropland Dry	Texas Cropland Irrigated	Texas Pasture Land	Texas Range Land	Texas Other Land	Texas Total Land	Basin Cropland Dry	Basin Cropland Irrigated	Basin Pasture Land	Basin Range Land	Basin Other Land	Basin Total
1975																		
Total Acres (1000)	1915	-	461	2121	-	4497	3773	1394	266	7994	104	13531	5688	1394	727	10115	104	18028
Adequately Treated Acres (1000)	1324	-	305	1160	-	2789	1779	406	81	3118	63	5447	3103	406	386	4278	63	8236
Percent Adequately Treated	69	-	66	54	-	62	47	29	30	39	60	40	55	29	53	42	60	46
2000																		
Total Acres (1000)	1970	-	524	2018	-	4512	4314	855	264	7899	104	13436	6284	855	788	9917	104	17948
Adequately Treated Acres (1000)	1478	-	386	1360	-	3224	2240	511	102	3926	79	6858	3718	511	488	5286	79	10082
Percent Adequately Treated	75	-	74	67	-	71	52	60	39	50	75	51	59	60	61	53	75	56
2020																		
Total Acres (1000)	2184	-	341	1993	-	4518	4761	408	264	7797	104	13335	6945	408	605	9790	104	17852
Adequately Treated Acres (1000)	1779	-	273	1594	-	3646	2843	367	119	4580	92	8001	4622	367	392	6147	92	11557
Percent Adequately Treated	81	-	80	80	-	81	60	90	45	59	88	59	67	90	65	63	88	64

1/ Irrigated cropland included with dry cropland
2/ Included in other uses

Source: SCS

Only a small percent of the total agricultural land will be converted to other land uses. The change will occur as the ground water level declines. Approximately 70 percent of cropland irrigated in 1970 will be converted to other agricultural land uses, primarily to dry cropland, by 2020.

Basinwide, the amount and percentage of land adequately treated is expected to increase in each period. The rate will decrease after 2000 when the more progressive and cooperative land users adequately treat their land. About 56 percent will be adequately treated by 2000.

By 2020 approximately 64 percent of the land will be adequately treated. The land adequately treated will probably reach an equilibrium at this level due to areas infeasible to treat, constant changes in ownership and reluctance of landowners to install needed conservation measures because of the low rate of monetary return.

Archeological and Historical Sites

Present inventories list 3,000 archeological sites and 128 historical sites in the basin. The State archeological officer keeps a record of these sites. As investigations are made and new sites discovered this information is sent to the State archeological officer. If the site is significant, it is nominated for the national register of archeological sites.

Due to the increased emphasis placed on our environment, it is estimated that the archeological sites will increase to 3,020 by the year 2000 and 3,050 by the year 2020. Historical site discoveries are estimated to increase to 132 by the year 2000 and 135 by 2020.

RESOURCE DEVELOPMENT NEEDS

RED RIVER BASIN ABOVE DENISON DAM

CHAPTER 7

RESOURCE DEVELOPMENT NEEDS

INTRODUCTION

Resource development needs were determined for this study to address the basin problems identified. Study concerns were established in the Plan of Work and modified as the study progressed. These study concerns were translated into the major planning objective to which they are primarily related.

Emphasis was given to determining gross needs under present conditions and projected needs for 2000 and 2020 without accelerated resource development activities. Those needs that could be satisfied with existing projects and on-going programs were deducted from gross needs for 2000 and 2020.

SPECIFIC DESCRIPTION FOR COMPONENT NEEDS

Economic Development

Floodwater Damage Reduction: The basin's upstream watersheds were all investigated and total flood damages were determined for each watershed. Potential for reducing floodwater damages was determined by evaluating most watersheds with floodwater retarding structures.

Structure criteria provided for 25-year frequency agricultural protection and 100-year frequency urban protection. Structural costs and damage reduction were determined as were benefit-cost ratios which resulted in economical and uneconomical projects. This analysis provided the basis by which watershed potential was established.

One hundred and sixty five watersheds were identified in the basin and classified according to project status, Table 7-1. Of this total, 66 watersheds are part of an authorized PL-534 watershed. There are 99 watersheds outside of the authorized PL-534 area. Fifteen of the 99 watersheds have authorized structural plans for flood protection. The remaining 84 watersheds have a total of 1,001,900 acres of flood plain with no protection except land treatment measures. Of this total, 385,000 acres are in Oklahoma and 617,000 acres are in Texas, Table 7-2.

Watershed Status for Flood Damage Reduction

Red River Basin Above Denison Dam

Watershed Status 1/	Washita PL-534 Oklahoma	Washita PL-534 Texas	PL-566 Oklahoma	PL-566 Texas	Basin Total
	----------	----------	Number	----------	----------
Completed (SCS)	29	1	2	0	32
In operation (SCS)	25	0	7	3	35
Approved for operation (SCS)	2	0	1	1	4
Being Planned (SCS)	0	0	0	1 2/	1
Corps of Engineers Projects 3/	0	0	0	0	2
Bureau of Reclamation	0	0	0	0	5
SUB-TOTAL	56	1	10	5	79
Potential projects	(2) 6/	0	17	2 4/	19
No potential (currently) 5/	(7)	0	15	50	65
Component need	(2) 6/	0	17	2	19

1/ Expected status through the year 2000
2/ Included in both being planned and potential projects category
3/ Includes Texoma
4/ Includes one watershed with portions in both Texas and Oklahoma
5/ Included 4 watersheds with portions of watershed in both Texas and Oklahoma
6/ Needs will be met under authority of PL-534

Source: SCS

TABLE 7-2

Flood Damage Reduction Needs

Red River Basin Above Denison Dam

	Oklahoma	Texas	Basin Total
		acres	
Existing Flood Problems (No Structural Protection)	385,000	617,000	1,001,900
Subject to Minor Damages (No Potential Currently)	199,000	608,600	807,600
Needing Flood Damage Reduction (Potential Projects)	186,000	8,400	194,400

Source: River Basin Staff, SCS

Investigations reveal that 19 of the 84 watersheds have flood losses and associated problems of such magnitude that remedial measures are justified. The remaining 65 watersheds also have urban and rural flood damages; however, under current criteria and economic conditions, it is not economically feasible to provide structural protection for these watersheds.

Water Supply: The municipal and industrial water needs (which include rural, urban, industrial and utility) are the total demand less anticipated supply at time frame considered. The total demand is based upon the projected total population and per capita usage for each urban and rural community in the basin. Population projections were obtained from Oklahoma Employment Security Commission report. The projections for the Texas portion was based on a report by the Texas Water Development Board. The anticipated water supplies are based on studies determining quantities and quality for time frame studied.

The nonagricultural water needs for the Oklahoma portion for the year 2000 are 13,807 acre-feet per year, which includes 371 rural, 1,765 urban and industry, and 11,671 utility. The nonagricultural water needs for the year 2020 are 29,007 acre-feet per year which includes 717 rural, 6,390 urban and industry, and 21,900 utility, Table 7-3. Plate 7-1 shows the existing and proposed major reservoirs for the basin.

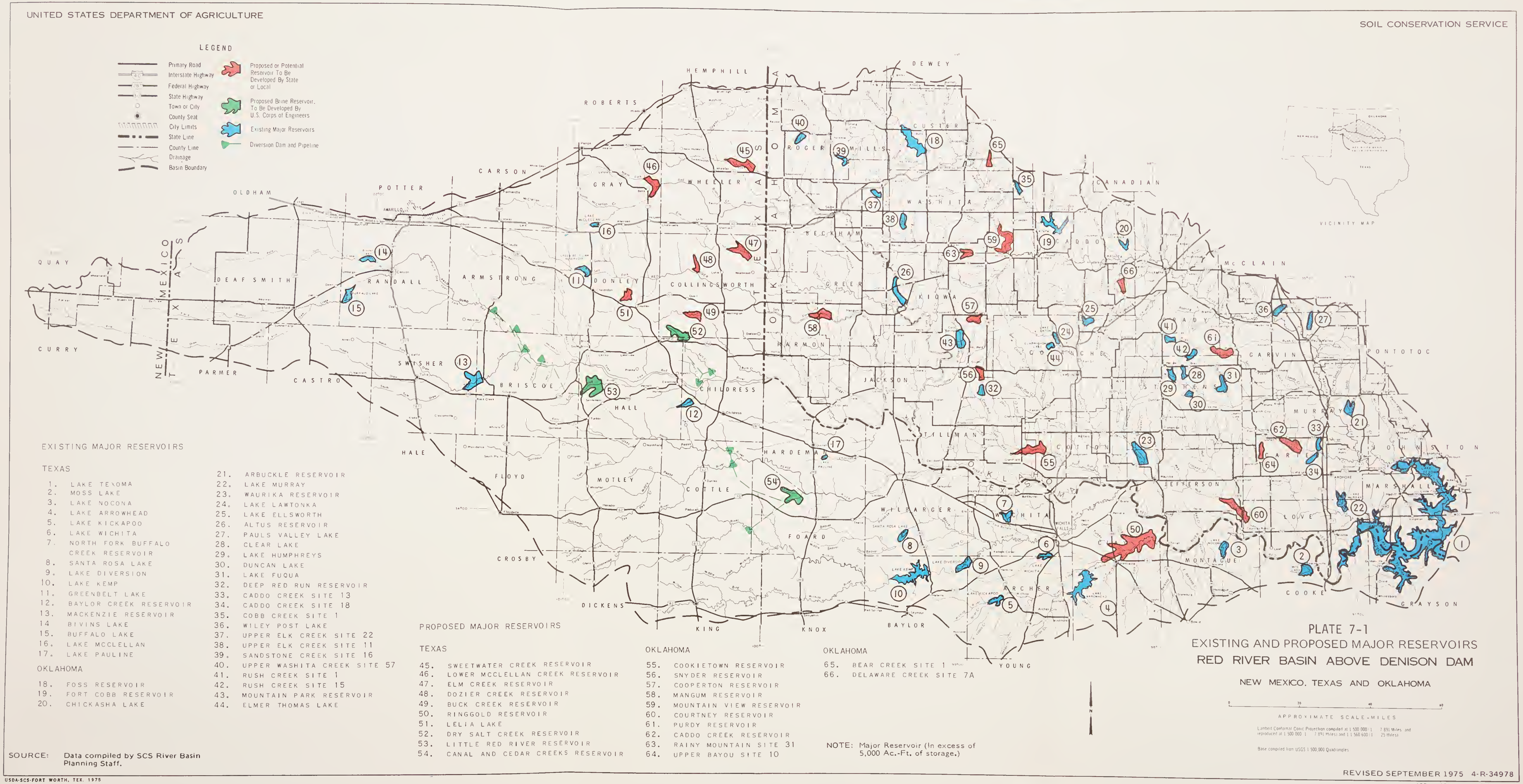
TABLE 7-3

Water Supply Needs

Red River Basin Above Denison Dam

	Oklahoma		Texas		Total	
Use	2000	2020	2000	2020	2000	2020
	Acre-Feet					
Irrigation	475480	1153880	1283000	1942800	1758480	3096680
Nonagricultural	13807	29007	-	-	13807	29007
Basin Total	489787	1182887	1283000	1942800	1772287	3125687

Source: Compiled by SCS from TWDB and OWRB data.


UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
LEGEND
Primary Road
Interstate Highway
Federal Highway
State Highway
Town or City
County Seat
City Limits
State Line
County Line
Drainage
Basin Boundary
Proposed or Potential Reservoir To Be Developed By State or Local
Proposed Brine Reservoir, To Be Developed By U.S. Corps of Engineers
Existing Major Reservoirs
Diversion Dam and Pipeline
EXISTING MAJOR RESERVOIRS
TEXAS
1. LAKE TEXOMA
2. MOSS LAKE
3. LAKE NOCONA
4. LAKE ARROWHEAD
5. LAKE KICKAPOO
6. LAKE WICHITA
7. NORTH FORK BUFFALO CREEK RESERVOIR
8. SANTA ROSA LAKE
9. LAKE DIVERSION
10. LAKE KEMP
11. GREENBELT LAKE
12. BAYLOR CREEK RESERVOIR
13. MACKENZIE RESERVOIR
14. BIVINS LAKE
15. BUFFALO LAKE
16. LAKE MCCLELLAN
17. LAKE PAULINE
OKLAHOMA
18. FOSS RESERVOIR
19. FORT COBB RESERVOIR
20. CHICKASHA LAKE
21. ARBUCKLE RESERVOIR
22. LAKE MURRAY
23. WAURIKA RESERVOIR
24. LAKE LAWTONKA
25. LAKE ELLSWORTH
26. ALTUS RESERVOIR
27. PAULS VALLEY LAKE
28. CLEAR LAKE
29. LAKE HUMPHREYS
30. DUNCAN LAKE
31. LAKE FUQUA
32. DEEP RED RUN RESERVOIR
33. CADDO CREEK SITE 13
34. CADDO CREEK SITE 18
35. COBB CREEK SITE 1
36. WILEY POST LAKE
37. UPPER ELK CREEK SITE 22
38. UPPER ELK CREEK SITE 11
39. SANDSTONE CREEK SITE 16
40. UPPER WASHITA CREEK SITE 57
41. RUSH CREEK SITE 1
42. RUSH CREEK SITE 15
43. MOUNTAIN PARK RESERVOIR
44. ELMER THOMAS LAKE
PROPOSED MAJOR RESERVOIRS
TEXAS
45. SWEETWATER CREEK RESERVOIR
46. LOWER MCCLELLAN CREEK RESERVOIR
47. ELM CREEK RESERVOIR
48. DOZIER CREEK RESERVOIR
49. BUCK CREEK RESERVOIR
50. RINGGOLD RESERVOIR
51. LELIA LAKE
52. DRY SALT CREEK RESERVOIR
53. LITTLE RED RIVER RESERVOIR
54. CANAL AND CEDAR CREEKS RESERVOIR
OKLAHOMA
55. COOKIETOWN RESERVOIR
56. SNYDER RESERVOIR
57. COOPERTON RESERVOIR
58. MANGUM RESERVOIR
59. MOUNTAIN VIEW RESERVOIR
60. COURTNEY RESERVOIR
61. PURDY RESERVOIR
62. CADDO CREEK RESERVOIR
63. RAINY MOUNTAIN SITE 31
64. UPPER BAYOU SITE 10
OKLAHOMA
65. BEAR CREEK SITE 1
66. DELAWARE CREEK SITE 7A
NOTE: Major Reservoir (In excess of 5,000 Ac.-Ft. of storage.)
SOURCE: Data compiled by SCS River Basin Planning Staff.
PLATE 7-1
EXISTING AND PROPOSED MAJOR RESERVOIRS
RED RIVER BASIN ABOVE DENISON DAM
NEW MEXICO, TEXAS AND OKLAHOMA
APPROXIMATE SCALE-MILES
VICINITY MAP
REVISED SEPTEMBER 1975 4-R-34978
USDA-SCS-FORT WORTH, TEX. 1975

Although the nonagricultural usage of water will more than double by year 2020 for Texas, this need can be met. The high plains portion of the basin will have a critical need for water. The city of Amarillo will continue to receive water from Lake Meredith via the Canadian River Aquaduct. The Mackenzie Reservoir will furnish municipal and industrial water to its member cities. Greenbelt Reservoir will provide a dependable supply for its member cities with a surplus to meet unforeseen future demands. Potential sites exist where reservoirs could be constructed to meet additional needs.

The Oklahoma Water Resource Board has estimated the current irrigation water demand or requirements for the Oklahoma portion of the basin. The net need or difference between the amount required and amount supplied is for an additional 152,000 acre-feet of water.

The Oklahoma Water Resources Board projects irrigation water requirements to increase to 475,500 acre-feet of water per year by the year 2000 and 1,153,900 acre-feet of water per year by the year 2020.

Under present trends of ground water decline the approximately 1.5 million acres currently irrigated in the Texas portion of the basin will decline to about 0.4 million by the year 2020. This projection by the Texas Water Development Board is the result of tests made each year of the water table in the High Plains Land Resource Area. The receding water levels indicate that the amount of irrigation which can be sustained by ground water pumping will eventually decline since the withdrawal exceeds the recharge rate. With water importation the acreage would increase to approximately 1.8 million acres. The water use at present averages 1.4 feet per acre irrigated. The irrigation water needs would be 1.3 million acre-feet for year 2000 and 1.9 million for 2020. Approximately 3.1 million acres are suitable for irrigation in the Texas portion. To irrigate all of the acres suitable would require importation of about 3.0 million acre-feet of water annually. There are no large potential reservoir sites with sufficient runoff yield to supply the needed water for irrigation.

There is a definite need, from an agricultural production standpoint, to produce more food and fiber to meet the projected needs, Table 7-4. The table gives the OBERS E' projections as well as the Future Without Condition.

TABLE 7-4

Needs for Additional Agricultural Production by Crop

Red River Basin Above Denison Dam

(Oklahoma)

2000					2020				
Item	Unit	OBERS E'	Future Without	Needs	Item	Unit	OBERS E'	Future Without	Needs
Wheat	bu.	50,822,700	43,348,700	7,474,000	Wheat	bu.	60,813,000	47,464,400	13,348,600
Grain Sorghum	bu.	8,594,500	6,398,000	2,196,500	Grain Sorghum	bu.	9,710,800	6,523,200	3,187,600
Alfalfa	ton	854,100	795,700	58,400	Alfalfa	ton	1,137,200	940,500	196,700
Cotton	lb.	75,815,300	75,815,300	-	Cotton	lb.	71,798,600	71,798,600	-
Peanuts	lb.	408,165,400	286,753,100	121,412,300	Peanuts	lb.	520,354,100	327,469,100	192,885,000

TABLE 7-4 (cont'd)

Needs for Additional Agricultural Production by Crop

Red River Basin Above Denison Dam

(Texas)

2000					2020				
Item	Unit	OBERS E'	Future Without	Needs	Item	Unit	OBERS E'	Future Without	Needs
Wheat	bu.	32,900,000	26,060,000	6,840,000	Wheat	bu.	34,965,300	26,945,800	8,019,500
Grain Sorghum	bu.	138,202,700	86,006,000	52,196,700	Grain Sorghum	bu.	156,112,900	75,976,700	80,136,200
Barley-Oats	bu.	8,323,800	5,245,100	3,078,700	Barley-Oats	bu.	10,299,900	4,113,900	6,186,000
Alfalfa	ton	360,700	290,700	70,000	Alfalfa	ton	479,000	250,000	229,000
Other Hay	ton	586,100	510,600	75,500	Other Hay	ton	778,400	406,300	372,100
Cotton	lb.	169,730,500	169,730,500	-	Cotton	lb.	189,436,400	189,436,100	-
Peanuts	lb.	23,669,500	23,669,500	-	Peanuts	lb.	29,720,000	29,715,700	-
Soybeans	bu.	5,835,600	1,694,900	4,140,700	Soybeans	bu.	6,492,500	957,500	5,535,000
Sugar Beets	ton	562,800	562,800	-	Sugar Beets	ton	687,900	687,900	-

Source: ERS

Outdoor Recreation: The recreational opportunities within the basin for most of the selected activities are unable to meet the present demand. As shown in Table 7-5, the participation in these activities will progressively increase from 1970 to 2020 as the population grows, higher incomes, and more leisure time is available.

Presently three activities, golf, outdoor games and water sports, have sufficient facilities to meet the demand. By 2020, water sports will be the only activity which can meet its demand.

The need for additional recreational facilities will vary within the basin. For example, water sports are sufficient to meet the basin needs, but due to poor distribution of facilities, the western portion of the basin has a present need. Most of these water resources are located in the eastern portion of the basin.

Fish and Wildlife Habitat: The method used to evaluate the need for additional fish and wildlife resources was fishing and hunting demand. Although a need may exist for nonconsumptive uses, it was assumed if the sportsman's needs were satisfied, then these additional resources would be sufficient to fulfill the nonconsumptive needs.

The present and projected needs for fishing and hunting are shown in Table 7-6 by activity day and accessible habitat. These days and acreages were determined from the public desires shown in Chapter 5 and the supply of resources or that portion of the existing habitat which was accessible to the public, as shown in Chapter 6. The fishery resource in Oklahoma is sufficient to fulfill their demand (desires), whereas Texas can only meet their present demand.

Neither Oklahoma nor Texas has sufficient resources to meet their demand for hunting.

This study did not address project-type USDA opportunities to satisfy the fish and wildlife needs. About 25 percent of the needs could be fulfilled under existing conditions with landowner incentives.

Private landowners could be educated to the income producing potential to making their lands accessible to hunting and fishing. Proper wildlife habitat management could increase species densities.

Table 7-5

Selected Recreational Activity Needs

Red River Basin Above Denison Dam

Activity		Oklahoma 1970	Oklahoma 2000	Oklahoma 2020	Texas 1970	Texas 2000	Texas 2020	Total 1/ 1970	Total 1/ 2000	Total 1/ 2020
Camping	1000 Activity Days	680	986	1146	1066	5674	7002	1746	6660	8148
	Sites	1133	1644	1910	2023	10767	13289	3156	12411	15199
Picnicking	1000 Activity Days	165	569	884	856	14209	21351	1021	14778	22235
	Sites	131	452	702	785	13024	19570	916	13476	20272
Swimming	1000 Activity Days	6782	9428	10832	876	22595	46288	7658	32023	57120
	1000 sq/yds	125.6	174.6	200.6	19.3	571	1202	144.9	745.6	1402.6
Golf	1000 Activity Days	0	136	249	0	207	865	0	343	1114
	Holes	0	54	99	0	48	201	0	102	300
Outdoor Games	1000 Activity Days	917	1391	1612	0	509	2455	0	1900	4067
	Acres	182	276	320	0	23	110	0	299	430
Combined Trails	1000 Activity Days	742	1113	1302	1254	6225	10659	1996	7338	11961
	Miles	110	165	193	224	1113	1907	334	1278	2100
Horseback Trails	1000 Activity Days	1641	2231	2535	0	2549	2856	1445	4780	5391
	Miles	486	661	751	0	69	142	428	730	893
Watersports	1000 Activity Days	0	0	0	0	0	3804	0	0	0
	Surface Acres	0	0	0	0	0	9637	0	0	0

1/ Note:
When zero (0) is shown, it means the demand is fulfilled and there are no needs. However, it does not mean that an equilibrium was reached, so when Texas and Oklahoma are combined, an excess need (0) in one state can satisfy a portion of the need in the other state.

Source: Compiled by SCS from TORP & SCORP data

TABLE 7-6

Fishing and Hunting Needs

Red River Basin Above Denison Dam

State	Unit	Fishing			Hunting		
		1970	2000	2020	1970	2000	2020
		1000					
Oklahoma	activity day	0	0	0	338	467	577
	acres	0	0	0	48	67	32
Texas	activity day	1030	8746	14964	547	2161	3507
	acres	193	1645	2814	3283	13947	21653
Basin	activity day 1/	0	3152	9799	885	2628	4084
	acres	0	13	136	3331	14014	21735

1/ Note:
When zero (0) is shown, it means the demand is fulfilled and there are no needs. However, it does not mean that an equilibrium was reached, so when Texas and Oklahoma are combined, an excess need (0) in one state can satisfy a portion of the need in the other state.

Source: Compiled by SCS

If the species density was increased on the suitable habitat to the average basin density, by stocking uninhabited areas and management of the existing habitat, the need for additional hunting resources could be delayed until 2020 and the fishing demand could be fulfilled.

A number of areas in the basin are important resources for fish and wildlife and should be protected and enhanced. These are the springs, wetlands, bottom lands, and other wooded habitat.

The springs are valuable resources both from the aesthetic viewpoint and the aquatic species associated with them.

The seasonally flooded flats (Type 1 wetland) which occur in the basin are valuable resting and feeding areas to the wintering and migrating waterfowl.

The two unique wetland areas - the Sweetwater Creek area in Wheeler County and the Gageby Creek and Washita River area in Hemphill County - comprise a total of 27,500 acres. These are unusual wetland ecosystems (Type III and IV wetlands) which include springs, streams, bogs, freshwater meadows, and marshes. An established population of beaver has constructed dams and ponds along the creeks, rivers, and tributaries. Egrets, herons, and other wading and shore birds are found in this area along with reptiles, amphibians, fish, and other wildlife associated with wetlands. At least two of the major and historical springs of Texas are in this area.

Generally, only remnants of the original woody vegetation actually exist in the basin. These areas, such as the bottom land or riparian hardwoods are ecologically important to the species restricted to these areas for their survival.

The management of invading brush species or invading woody vegetation could be applied to enhance wildlife as well as to improve livestock production.

Environmental Quality

Erosion and Sedimentation: Erosion and sedimentation reduction needs for 2000 and 2020 are shown in Tables 7-7 and 7-8. Gross erosion from all sources should be reduced by an estimated 32,251,700 tons by the year 2020. Sediment damages from overbank deposition should be reduced by 67,900 acres by the year 2000 and 120,600 acres by 2020. Wind erosion damages should be reduced by 116,400 acres by year 2000 and 250,600 acres by 2020.

TABLE 7-7

Needed Reductions in Gross Erosion (All Sources)

Red River Basin Above Denison Dam

Source	Oklahoma 2000	Oklahoma 2020	Texas 2000	Texas 2020	Basin Total 2000	Basin Total 2020
	------Tons Per Year------					
Sheet						
Cropland						
(Dry)	2,315,900	5,395,800	1,316,700	8,789,400	3,632,600	14,185,200
(Irrigated) 1/	-169,600	167,700	28,800	42,600	-140,800	210,300
Pastureland	419,500	665,800	8,000	16,000	427,500	681,800
Rangeland	1,434,500	2,715,900	828,600	1,806,000	2,263,100	4,521,900
Forest Land (grazed) 1/	-159,100	58,600	175,000	175,000	15,800	233,600
Other Land	-	-	2,500	5,400	2,500	5,400
Sub-total sheet erosion	3,841,200	9,003,800	2,359,600	10,834,400	6,200,300	19,838,200
Gully	2,608,400	2,912,800	980,000	1,903,300	3,588,400	4,816,100
Streambank	1,785,200	2,004,800	685,400	1,373,800	2,470,600	3,378,600
Roadside	1,431,200	1,598,300	156,400	414,000	1,587,600	2,012,300
Flood Plain Scour	1,125,000	1,687,500	258,500	519,000	1,383,500	2,206,500
GRAND TOTAL (Net)	16,791,000	17,207,200	4,439,000	15,044,500	15,230,900	32,251,700

1/ The negative values result from the subtraction of the desired future amounts from the future without amounts to arrive at the needs. They reflect an increase in erosion under desired future conditions due primarily to land use changes.

Source: SCS and FS

TABLE 7-8

Needed Reductions in Land Lost and Damaged by Erosion and Tons of Sediment Delivered
Red River Basin Above Denison Dam

Item	Oklahoma		Texas		Basin Total	
	2000	2020	2000	2020	2000	2020
Sediment Delivered by Source 1/	Tons Per Year					
Sheet erosion 2/	777,200	1,709,700	475,900	2,132,400	1,253,100	3,842,100
Gully erosion	741,400	715,600	882,100	1,713,000	1,623,500	2,428,600
Streambank erosion	714,000	802,000	616,800	1,236,400	1,330,800	2,038,400
Roadside erosion	357,800	399,600	140,700	372,600	498,500	772,200
Flood Plain Scour	639,900	718,600	252,600	467,100	892,500	1,185,700
Acres Lost by Source	Acres Per Year					
Gully erosion	51	58	38	72	89	130
Streambank erosion	39	44	32	64	71	108
Acres Damaged by Source:	Acres Per Year					
Scour	26,200	41,000	12,400	25,100	38,600	66,100
Wind	35,400	88,700	81,000	161,900	116,400	250,600
Overbank deposition	40,600	66,000	27,300	54,600	67,900	120,600
	Tons Per Year					
Sediment Delivered to Lake Texoma	1,358,600	2,445,500	1,201,100	2,853,900	2,559,700	5,299,400

1/ Delivered to mouths of watersheds.
2/ Includes Forest land

Source: SCS and FS

Presently about 16 million tons of sediment are delivered to Lake Texoma per year. This total should be reduced by 5.3 million tons per year by year 2020.

Archeological and Historical Resources: The basin contains 1,927 recognized archeological sites and 128 historical sites, although more archeological sites are expected to exist. There will be a need to preserve an additional 20 archeological sites by the year 2000 and an additional 30 sites by 2020. The number of known historical sites is expected to increase to 132 by the year 2000 and to 135 sites by 2020. The needs include those additional archeological sites that will be inventoried and classified. Those sites which are significant will need to be preserved and protected. Table 7-9 shows the projected significant sites.

TABLE 7-9

Current and Projected Archeological and Historical Sites

Red River Basin Above Denison Dam

	Current	Archeological 2000	2020
Texas	1,077	1,097	1,127
Oklahoma	850	850	850
Basin Total	1,927	1,947	1,977
		Historical	
Texas	108	112	115
Oklahoma	20	20	20
Basin Total	128	132	135

Source: River Basin Staff, SCS

Coordination of historical and archeological site identification and preservation is done at the State level. Valuable assistance is provided through local groups throughout the State as well as regional and State archeological societies. The local organizations can assist by erecting historical markers, increasing public awareness, and by organizing local fund-raising efforts for site acquisition.

Table 7-10 summarizes the component needs for the basin.

TABLE 7-10

Specific Components and Component Needs, Present and Projected

Red River Basin Above Denison Dam

Specific Components	Component Needs	Units	Oklahoma Present	Oklahoma 2000	Oklahoma 2020	Texas Present	Texas 2000	Texas 2020	Basin Total Present	Basin Total 2000	Basin Total 2020
ECONOMIC DEVELOPMENT											
1. Increased productivity of land for more efficient output of food and fiber	Flood Reduction	Acres	186000	186000	186000	8400	8400	8400	194400	194400	194400
	Flood Plain Scour	Acres	0	26200	40943	0	12400	25100	0	38625	65923
	Sheet Erosion Damage Reductions	Tons	0	3841200	9003800	0	2181600	10659400	0	6231400	19663200
	Wind Erosion	Acres	0	35400	88700	0	81000	161900	0	116300	250600
	Overbank Deposition on Flood Plains	Acres	0	40600	66000	0	27300	54600	0	67900	120600
2. Increase or improve recreational services	Camping	A-D	680	986	1146	1066	5674	7002	1746	6660	8148
	Picnicking	A-D	165	569	884	856	14209	21351	1021	14778	22235
	Swimming	A-D	6782	9128	10832	876	22595	46288	7658	32023	57120
	Golf	A-D	0	136	249	0	207	865	0	343	1114
	Watersports	A-D	0	0	0	0	0	3804	0	0	0
	Horseback riding	A-D	1611	2231	2535	0	2549	2856	1445	4780	5391
	Combined trails	A-D	712	1113	1302	1254	6225	10659	1996	7338	11951
	Outdoor games	A-D	917	1391	1612	0	509	2455	0	1900	4067
3. Increase hunting and fishing opportunities	Fishing	A-D	0	0	0	0	6663	12753	0	6663	12753
	Hunting (1,000)	A-D	440	569	678	547	2161	3502	987	2730	4180
4. Increase and/or stabilize output of food and fiber & other goods and services	Non-agricultural Water	Ac.-Ft.	827	13807	29007	0	0	0	827	13807	29007
	Irrigation Water	Ac.-Ft.	148570	475480	1153880	0	1283000	1942800	148570	1758480	3096680
ENVIRONMENTAL QUALITY											
5. Improve quality of land, air, and water											
a. Improve water quality	Reduce sediment delivered to Lake Texoma	Tons	0	1358600	2445500	0	1201100	2853900	0	2559700	5299400
b. Reduction in non-point critical erosion	Critical erosion reductions										
	Gully	Gross Tons	0	2608400	2912800	0	980000	1903300	0	3588400	4816100
		Acres	0	51	58	0	38	72	0	89	130
	Streambank	Gross Tons	0	1735200	2004800	0	685400	1373800	0	2470600	3378600
		Acres	0	39	44	0	32	64	0	71	108
	Roadside	Gross Tons	0	1431200	1598300	0	156400	414000	0	1587600	2012300
	Flood plain scour	Gross Tons	0	1125000	1687500	0	258500	519000	0	1383500	2206500
c. Improve air quality	Wind	Acres	0	35400	88700	0	81000	161900	0	116400	250600
6. Preservation of archeological and historical sites, and unique areas	Preservation of archeological sites,	Number	850	850	850	1077	1097	1127	1927	1947	1977
	historical sites,	Number	20	20	20	108	112	115	128	132	165
	wetland areas	Acres	0	0	0	0	27500	0	0	27500	0
7. Increase, protect, and improve fish and wildlife habitat	Habitat Management Fishery	Acres	0	0	0	0	125725	240624	0	125725	240624
	Wildlife	Acres	0	1025273	1824254	3282540	13947000	21653000	3282540	14972273	23477254

Source: SCS and FS

DEVELOPMENT OPPORTUNITIES AND IMPACTS

RED RIVER BASIN ABOVE DENISON DAM

CHAPTER 8

DEVELOPMENT OPPORTUNITIES AND IMPACTS

USDA PROGRAM OPPORTUNITIES

The study concerns as identified previously for each of the objectives provide the basis for USDA program opportunities. Specific components for the objectives were identified from the study concerns. The sponsors provided input for the study concerns and the specific components of the objectives. The kinds of preferred outputs desired as a result of the study are also presented.

Emphasis was placed on major problems. Land use to meet the demands for crop and pasture products and other competitive demands was developed. Generally, rangeland acreage was that land left after other demands were met.

Evaluations were also made that concern the preservation of unique areas, archeological sites, and historical sites.

Projections presented in previous chapters are a manifestation of the study concerns of basin residents and sponsors of the study. The USDA program opportunities provide elements that meet part of the component needs. The effectiveness of the realization of the USDA program potentials within the basin is measured by the number of needs met.

The USDA program opportunities provide a means for the solution to some of the major water and related land problems of the basin.

Opportunities for resource development in the basin include both land treatment and structural measures for reducing economic losses due to floods, inadequate drainage, soil loss, sedimentation, land loss, and pollution. These measures are designed to provide better economic opportunities by enhancing both the quantity and quality of recreation, fish and wildlife habitat, changed land use, increased crop yields, increased wood production, and improvement of the environment. Although other programs and needs were identified, programs of local, State, and other Federal agencies should be considered.

USDA PROGRAM ELEMENTS

Resource Management Systems

Essential elements of an effective land and water management system include land treatment measures and management systems. The installation of an effective land treatment and management system program is basic for the development of water and related land resources.

Resource management systems may include crop residue management, cover crops, terraces, grassed waterways, contour farming, water management, or permanent grass cover.

For each land use there is a combination of conservation practices and management which will protect the resource base and improve the standard of living with minimal adverse effect on the environment. The proper combination depends upon the objectives of the landowner, climate, topography, soils, and condition of the landscape. Any combination contains the essential practices necessary to adequately treat the land.

Oklahoma has eight watersheds that will need accelerated land treatment. It was assumed that these eight watersheds will have 80 percent of the land area adequately treated by 2000 with accelerated land treatment which consists of cropland 33,608 acres, pastureland 8,769 acres, and rangeland 30,923 acres. No acceleration in land treatment is needed for the remaining watersheds for the year 2020 for it is assumed that Oklahoma will reach its desired level of 80 percent adequately treated acres with going programs.

There is a need for critical area stabilization throughout the basin in Oklahoma. Measures needed include grade stabilization structures, shaping and sodding, and critical area planting. Supplemental plans for the Washita River have been implemented to provide for applying these measures. Plans are needed to implement these measures outside of the Washita River. Emphasis will be given to this problem for the 17 feasible watersheds. With the increased interest in reducing non-point pollution, it is assumed that these needs will be solved through various programs and local participation by the year 2000.

In Texas, future installation of resource management systems were projected at two rates as shown in Figure 8-1. Based on historical data and agency experience with the present on-going programs, 60 percent of the land could attain the adequately treated status by 2020. The second rate assumes a realistic goal of 80 percent of the land to be adequately treated by 2020 if monetary incentives are available. It would be difficult

to obtain a higher degree because of ownership change, areas infeasible to treat, and the reluctance of some people to install conservation measures. The shaded area denotes the amount of land which could be adequately treated with installation of resource management systems shown in Figure 8-1.

FIGURE 8-1

Future Land Treatment

Red River Basin Above Denison Dam

(Texas)

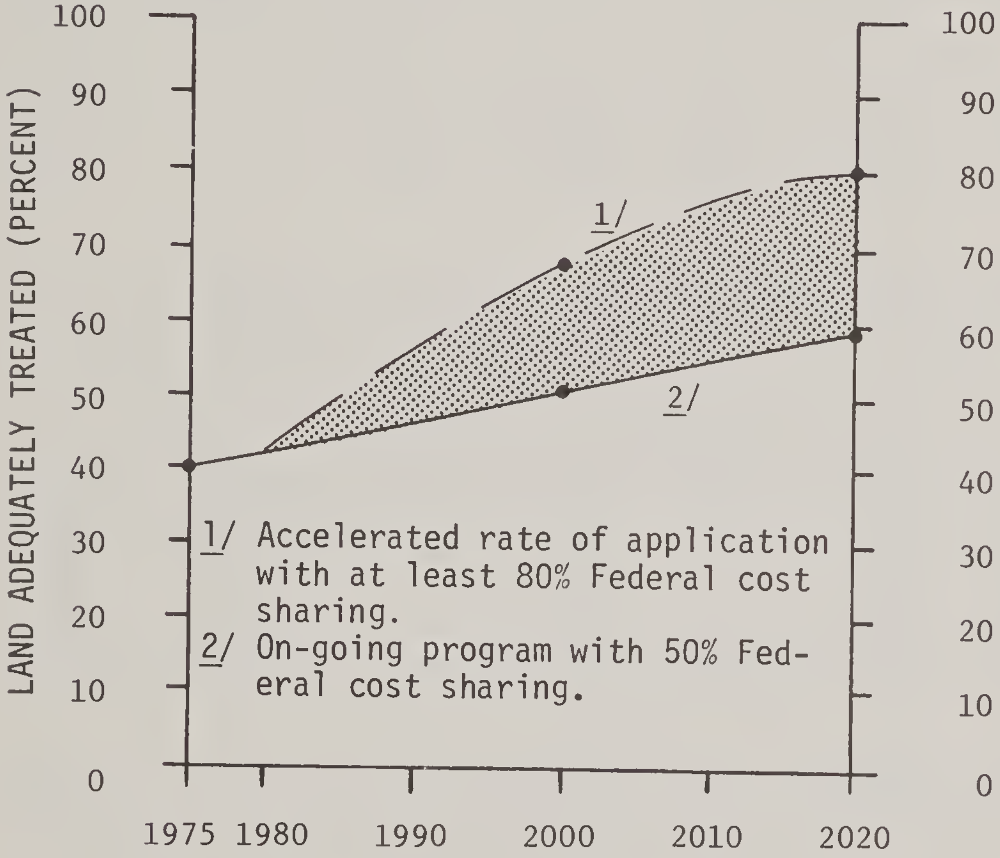


Table 8-1 shows approximately one million acres of cropland and 1.5 million acres of rangeland in Texas would be adequately treated by 2020 if the opportunity for acceleration of the application of resource management systems becomes a reality.

It was assumed that sediment reduction is directly proportional to erosion reduction and that erosion cannot be totally eliminated.

TABLE 8-1

Components and Elements of USDA Opportunities

Red River Basin Above Denison Dam

Components and Elements	Texas 2000	Texas 2020
	acres	
Resource Management Systems		
Cropland	936,000	1,097,000
Pastureland	34,000	40,000
Rangeland	1,304,000	1,527,000
Other Land	4,000	2,000

Source: River Basin Staff, SCS

Opportunities to reduce sediment load are closely tied to conservation measures for erosion control. These measures include conservation land treatment on cropland, pastureland, forest land, and other non-point sediment source areas. The combined effects of all measures, will reduce the amount of sediment delivered to Lake Texoma by 991,300 tons per year. Seventeen watersheds in Oklahoma and two in Texas will provide structures having sediment pools for the entrapment of sediment.

Most of the land treatment measures result in erosion damage reduction and protection of the land base with the accompanying increase in soil productivity and management efficiency.

Elements within USDA program opportunities would reduce gross sheet erosion by 800,600 tons annually, scour damage on 14,650 acres annually, and sediment damage on 25,300 acres of flood plain annually, by the year 2020, Table 8-10.

Structural Measures
USDA Program Opportunities

Flood Damage Reduction: There are 19 watersheds within the basin that have potential for development as feasible flood control projects under the present PL-566 program, Table 8-2. These watersheds are not authorized for construction. Ten of

TABLE 8-2

USDA Program Opportunities
Structural Measures, Average Annual Costs, and Average Annual Benefits

Red River Basin Above Denison Dam

Watershed		Channel Modification	Floodwater Retarding	Multi-Purpose	Average Annual ED Costs 1/				Average Annual EQ Costs 1/				Total ED and EQ Costs 1/				Average Annual Benefits 2/					ED	Overall
No.	Name	Miles	Strs. No.	Strs. No.	Project Inst.	Project Adm.	O&M	Total ED	Project Inst.	Project Adm.	O&M	Total EQ	Project Inst.	Project Adm.	O&M	Grand Total	Floodwater Damage Reduction	Non-Agri. Water Mgt.	Agri. Water Mgt.	Recreation	Total	Benefit Cost Ratio	Benefit Cost Ratio
	Watersheds by Year 2000																						
Oklahoma Portion																							
28	Sweetwater	-	10	4	226,100	56,700	4,200	287,000	-	-	-	-	226,100	56,700	4,200	287,000	320,300	-	24,402	-	344,702	1.2:1.0	1.2:1.0
126	Lower Mud	-	7	19	423,000	57,500	18,000	498,500	27,800	3,500	5,500	36,600	450,800	60,800	23,500	535,100	432,200	10,700	364,200	60,000	867,100	1.6:1.0	1.6:1.0
127	Upper Mud	-	21	4	249,500	43,000	12,100	304,600	-	-	-	-	249,500	43,000	12,100	304,600	263,000	-	158,000	-	421,000	1.4:1.0	1.4:1.0
130	Whiskey	-	6	3	78,600	14,200	3,600	96,400	-	-	-	-	78,600	14,200	3,600	96,400	145,100	-	28,500	-	173,600	1.8:1.0	1.8:1.0
133	Lower Beaver (above Waurika)	-	1	-	15,400	2,800	800	19,000	-	-	-	-	15,400	2,800	800	19,000	25,500	-	-	-	25,500	1.3:1.0	1.3:1.0
134	Lower Beaver (below Waurika)	-	2	2	53,400	10,200	3,100	66,700	-	-	-	-	53,400	10,200	3,100	66,700	71,600	-	17,200	-	88,800	1.3:1.0	1.3:1.0
136	Little Beaver	-	30	-	259,200	47,200	13,200	319,600	1,300	200	100	1,600	260,500	47,400	13,300	321,200	519,300	-	-	-	519,300	1.6:1.0	1.6:1.0
137	Big Beaver	16	63	-	261,100	59,300	14,500	334,900	-	-	-	-	261,100	59,300	14,500	334,900	366,100	-	-	-	366,100	1.1:1.0	1.1:1.0
	Subtotal	16	140	32	1,566,300	290,900	69,500	1,926,700	29,100	3,500	5,600	38,200	1,595,400	294,400	75,100	1,964,900	2,143,100	10,700	592,302	60,000	2,806,102	1.4:1.0	1.4:1.0
	Added Measures to Planned Projects																						
	PL- 534	-	-	29 3/	274,200	91,400	7,400	373,000	244,900	38,500	40,300	323,700	519,100	129,900	47,700	696,700	-	154,571	381,546	170,665	706,782	1.0:1.0	1.0:1.0
	PL- 566	-	-	10 3/	106,500	35,500	2,900	144,900	-	-	-	-	106,500	35,500	2,900	144,900	-	-	148,256	-	148,256	1.0:1.0	1.0:1.0
	Subtotal	-	-	39	380,700	126,900	10,300	517,900	244,900	38,500	40,300	323,700	625,600	165,400	50,600	841,600	-	154,571	529,802	170,665	855,038	1.0:1.0	1.0:1.0
	Oklahoma Total	16	140	71	1,947,000	417,800	79,800	2,444,600	274,000	42,000	45,900	361,900	2,221,000	459,800	125,700	2,806,500	2,143,100	165,271	1,122,104	230,665	3,661,140	1.3:1.0	1.3:1.0
Texas Portion																							
14	Afton Area	-	7	-	95,900	13,300	2,800	112,000	-	-	-	-	95,900	13,300	2,800	112,000	208,900	-	-	1,400	210,300	1.9:1.0	1.9:1.0
28	Sweetwater 4/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Texas Total	-	7	-	95,900	13,300	2,800	112,000	-	-	-	-	95,900	13,300	2,800	112,000	208,900	-	-	1,400	210,300	1.9:1.0	1.9:1.0
Basin Total (Year 2000)		16	147	71	2,042,900	431,100	82,600	2,556,600	274,000	42,000	45,900	361,900	2,316,900	473,100	128,500	2,918,500	2,352,000	165,271	1,122,104	232,065	3,871,440	1.4:1.0	1.3:1.0
	Watersheds by Year 2020																						
Oklahoma Portion																							
128	Fleetwood and Red	-	12	7	181,000	33,800	9,100	223,900	22,200	3,800	3,600	29,600	203,200	37,600	12,700	253,500	149,900	13,400	71,800	18,500	253,600	1.0:1.0	1.0:1.0
138	Lower East Cache	-	12	7	342,700	47,000	13,100	402,800	29,000	3,400	6,700	39,100	371,700	50,400	19,800	441,900	408,300	6,700	258,700	110,000	783,700	1.7:1.0	1.8:1.0
140	Upper East Cache	-	4	-	30,500	5,800	2,100	38,400	-	-	-	-	30,500	5,800	2,100	38,400	38,400	-	-	-	38,400	1.0:1.0	1.0:1.0
143	Lower Deep Red Run	-	3	8	211,300	32,700	9,500	253,500	4,700	700	700	6,100	216,000	33,400	10,200	259,600	384,500	2,700	139,600	45,000	571,800	2.1:1.0	2.2:1.0
145	Middle Deep Red Run	-	21	4	317,500	51,300	14,300	383,100	-	-	-	-	317,500	51,300	14,300	383,100	321,800	-	60,000	-	381,800	1.0:1.0	1.0:1.0
150	Lower Elk	-	5	4	161,900	23,800	7,700	193,400	-	-	-	-	161,900	23,800	7,700	193,400	227,200	-	34,000	-	261,200	1.4:1.0	1.4:1.0
154	Upper North Fork	-	4	4	174,400	30,100	9,100	213,600	-	-	-	-	174,400	30,100	9,100	213,600	159,700	-	60,600	-	220,300	1.0:1.0	1.0:1.0
157	Gypsum	-	9	-	122,600	18,400	6,100	147,100	-	-	-	-	122,600	18,400	6,100	147,100	205,800	-	-	-	205,800	1.4:1.0	1.4:1.0
158	Lower Elm Fork	-	1	1	95,900	15,600	4,400	115,900	-	-	-	-	95,900	15,600	4,400	115,900	52,000	-	63,600	-	115,600	1.0:1.0	1.0:1.0
	Subtotal	-	71	35	1,637,800	258,500	75,400	1,971,700	55,900	7,900	11,000	74,800	1,693,700	266,400	86,400	2,046,500	1,890,100	22,800	688,300	173,500	2,852,200	1.3:1.0	1.4:1.0
	Added Measures to Planned Projects																						
	PL- 534	-	-	28 3/	285,500	95,100	7,700	388,300	-	-	-	-	285,500	95,100	7,700	388,300	-	-	397,167	-	397,167	1.0:1.0	1.0:1.0
	PL- 566	-	-	11 3/	119,300	39,800	3,200	162,300	-	-	-	-	119,300	39,800	3,200	162,300	-	-	165,968	-	165,968	1.0:1.0	1.0:1.0
	Subtotal	-	-	39	404,800	134,900	10,900	550,600	-	-	-	-	404,800	134,900	10,900	550,600	-	-	563,135	-	563,135	1.0:1.0	1.0:1.0
	Oklahoma Total	-	-	74	2,042,600	393,400	86,300	2,522,300	55,900	7,900	11,000	74,800	2,098,500	401,300	97,300	2,597,100	1,890,100	22,800	1,251,435	173,500	3,395,335	1.2:1.0	1.3:1.0
Texas Portion																							
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Basin Total (Year 2020)		-	71	74	2,042,600	393,400	86,300	2,522,300	55,900	7,900	11,000	74,800	2,098,500	401,300	97,300	2,597,100	1,890,100	22,800	1,251,435	173,500	3,395,335	1.2:1.0	1.3:1.0
Basin Grand Total		16	218	145	4,085,500	824,500	168,900	5,078,900	329,900	49,900	56,900	436,000	4,415,400	874,400	225,800	5,515,600	4,242,100	118,071	2,373,539	405,565	7,266,775	1.3:1.0	1.3:1.0

1/ Price base 1976 - amortized at 6.375 percent, 100 years for channels, 100 years for floodwater retarding structures. Operation and maintainance at current normalized prices. Water Resources Council, November 1975.
2/ Current normalized prices, Water Resources Council, November 1975.
3/ Modification of floodwater retarding structures.
4/ The project benefits and costs that accrue in Texas portion of the watershed are $123,500 and $91,000 respectively and are included with Oklahoma project information.

Source: SCS

these watersheds are: Afton Area No. 14, Sweetwater Creek No. 28, Lower Mud Creek No. 126, Upper Mud Creek No. 127, Whiskey Creek No. 130, Lower Beaver Creek (above Waurika Reservoir) No. 133, Lower Beaver Creek (below Waurika Reservoir) No. 134, Little Beaver Creek No. 136, and Big Beaver Creek No. 137. Lower Sweetwater is located in both Oklahoma and Texas.

The structural measures included in these 10 watersheds consist of 147 single purpose structures, 32 multi-purpose structures and 16 miles of channel improvement. The 32 multi-purpose structures consist of two with municipal, recreation and flood storage, and 30 with irrigation and flood storage. These floodwater retarding structures will control 1,800 square miles of drainage and will provide protection to 200,700 acres of flood plain land. The sediment and detention storage are 60,900 and 177,000 acre-feet respectively.

Municipal and Industrial Water Supply: A portion of the municipal and industrial water needs within the basin for the year 2000 can be met by the two multi-purpose reservoirs planned. Also three watershed projects planned under PL 78-534 program will supply municipal needs by altering one presently built structure and adding two structures to these watersheds. These measures will provide 2,900 acre-feet per year of these needs by year 2000, plus additional supply to meet added needs for 2020. In most instances, complete water supplies would be provided with these structures due to inadequacy of present supplies.

Recreational Water Supply: Generally the water-based recreation needs have been met for the basin, but there are still local needs throughout the basin. Therefore, recreational storage and developments are planned in conjunction with multi-purpose structures that have municipal storage included. These five structures will provide 785 surface acres of water-based recreation. Also recreation developments are planned near these water surface areas to provide additional recreational needs.

Irrigation Water Supply: Irrigation needs have been identified in all counties of the basin. These needs exceed the present supplies capabilities. Therefore, consideration is given to providing a portion of these needs through multi-purpose structures which include both irrigation and flood storage. These needs are projected to be 475,500 and 1,153,900 acre-feet per year by 2000 and 2020 respectively for Oklahoma.

As identified previously, a portion of these needs will be met with multi-purpose structures from the seventeen watersheds in Oklahoma. Also there are a number of PL 78-534 and PL 83-566 structures that have been built that will be altered to store

water for multiple uses. It is estimated that these structures could be altered to produce 27,000 acre-feet of water per year that is suitable for irrigation. However, 7,000 acre-feet of this is located in the Washita basin between Clinton and Verden where multiple stream water rights have been issued. A detailed study would be necessary to determine the availability of these waters. It is assumed that approximately half of these structures would be altered by 2000 and the remainder by 2020. Table 8-3 shows potential yield by counties from altered (PL 78-534 and PL 83-566) structures and from the structures in the 17 feasible watersheds in Oklahoma. These exceed needs for some areas.

The Soil Conservation Service indicates that 12,900 acre-feet will be supplied by supplementing watershed plans presently authorized and 15,300 acre-feet will be supplied by potential watersheds by the year 2000. This is a total of 28,200 acre-feet of water that will be supplied by Soil Conservation Service projects leaving a net unfulfilled need for 447,300 acre-feet of water.

Also the Soil Conservation Service indicates that 26,700 acre-feet will be supplied by supplementing watershed plans presently authorized and 34,500 acre-feet will be supplied by potential feasible watershed projects. This is a total of 61,200 acre-feet that will be supplied by Soil Conservation Service projects leaving a net unfulfilled need for 1,092,700 acre-feet.

Nine of the 19 feasible watersheds are included in the second category. These are: Fleetwood Red No. 128, Lower East Cache No. 138, Upper East Cache No. 140, Lower Deep Red Run No. 143, Middle Deep Red Run No. 145, Lower Elk No. 150, Upper North Fork No. 154, Gypsum No. 157, and Lower Elm Fork No. 158. All of these watersheds are in Oklahoma.

These structural measures included in these nine watersheds consist of 71 single purpose structures and 35 multi-purpose structures. The 35 multi-purpose structures consist of two with municipal, recreation and flood storage and 33 with irrigation and flood storage. These floodwater retarding structures will control 770 square miles of drainage and will provide protection to 121,400 acres of flood plain land. The sediment and detention storage are 66,000 and 132,000 acre-feet respectively. A portion of the municipal and industrial needs can be met by the 2,900 acre-feet per year these structures will provide. Also these structures will provide 1,580 surface acres for water-based recreation with recreational developments planned near these water surfaces.

TABLE 8-3

Potential Local Water Sources
Red River Basin Above Denison Dam
(Oklahoma)

County	Irrigation Ac.Ft./Yr. Planned PL 78-534 and PL 83-566 1/ Structures	Irrigation Ac.Ft./Yr. Potential Feasible PL-566 Watersheds	Subtotal	Municipal Ac.Ft./Yr. Added PL 78-534 and PL 83-566 Structures	Total Ac.Ft./Yr.
Beckham	724	200	924	0	924
Bryan	0	0	0	0	0
Caddo	2,889	0	2,889	0	2,889
Canadian	0	0	0	0	0
Carter	6,214	0	6,214	0	6,214
Comanche	203	2,367	2,570	4,870	7,440
Cotton	0	9,167	9,167	0	9,167
Custer	833	0	833	0	833
Dewey	182	0	182	0	182
Garvin	2,316	0	2,316	2,647	4,963
Grady	2,482	0	2,482	0	2,482
Greer	110	1,720	1,830	0	1,830
Harmon	402	0	402	0	402
Jackson	352	0	352	0	352
Jefferson	0	11,819	11,819	2,812	14,631
Johnston	581	0	581	0	581
Kiowa	2,381	920	3,301	0	3,301
Love	1,917	689	2,606	521	3,127
Marshall	0	0	0	0	0
McClain	919	0	919	818	1,737
Murray	1,233	0	1,233	0	1,233
Pontotoc	0	0	0	0	0
Roger Mills	0	1,937	1,937	0	1,937
Stephens	1,056	4,010	5,066	0	5,066
Tillman	262	1,621	1,883	0	1,883
Washita	1,783	0	1,783	0	1,783
Total	26,839	34,450	61,289	11,668	72,957

1/ It is estimated that 7,130 acre-feet of this potential storage may not be available due to prior allocations.

Source: SCS

Non-Structural Measures: The Soil Conservation Service provides assistance to State and local governments in their flood plain management programs as provided by Section 6 of PL 83-566. The objective of flood hazard analyses is to furnish flood hazard data and technical assistance needed by local governments in implementing their local flood plain management measures.

The National Flood Insurance Program can provide some relief from future damages. Other Federal agencies such as the Corps of Engineers and Bureau of Reclamation may provide protection to additional acres. Local zoning ordinances could regulate urban built-up in flood prone areas and prevent an increase in future damages.

There are 86 towns or cities within the basin which have been identified as having flood problems. Flood hazard analyses maps will be completed for five of these by the year 1980. Six additional flood hazard analyses will be made by the year 2000. The remaining 75 towns or cities with flood problems should have flood insurance studies made which will also identify flood problem areas. These studies are programmed by the Federal Insurance Administration.

Additional methods may reduce future flood problems and damages. Zoning of the flood prone area to limit construction of homes, industry, or business will reduce the hazards. Also flood proofing of buildings within the flood prone area would reduce these hazards.

ENVIRONMENTAL CONSIDERATIONS

Development produces both beneficial and adverse effects on the basin's environment. Structural measures to reduce flooding require some flood plain lands, but generally the beneficial effects far exceed the detrimental effects. Conservation management systems are usually almost completely beneficial.

Consideration of the environment was of importance in selecting the elements of USDA programs which have development opportunities within the basin. Projects should have minimum detrimental effects and, when possible, should enhance the environment. The effects and changes that will result from project construction must be recognized and identified to assist in deciding how to plan, design, install, and maintain a project.

Upon authorization of the 19 feasible watersheds, environmental assessments will be conducted to determine impacts and need for mitigation and project modification to lessen the adverse environmental impacts. Methods of modification or mitigation of structures include wildlife plantings, preservation of significant

areas, change from permanent structure to dry structure status and minimum flow release. Environmental additions to channel modification plans include dredging and clearing from one side only - alternating sides by segment, retention of some pools, riffles, meanders, and reduction of land clearing during construction activities.

LEGAL AND INSTITUTIONAL ASPECTS

The USDA program opportunities can be implemented by Federal and State agencies presently in existence in many areas of the basin. However, the acceleration and expansion of programs to some parts of the basin require that local sponsors be organized under present authorities. Where the programs are to be planned and installed under the Watershed Protection and Flood Prevention Act (PL 83-566), a local or State sponsor must meet certain legal requirements before these projects can be initiated. Additional expansion of the present Resource Conservation and Development (RC&D) Projects to include additional areas under the Food and Agriculture Act (PL 87-703) and the Soil Conservation Act of 1935 (16 USC - 590 a-f) would be a means to implement some program elements.

Most of the basin is organized in soil and water conservation districts. The districts are eligible for assistance under the Soil Conservation Service Establishing Act (PL 74-46). However, to implement USDA program elements, the resource management systems on cropland, pastureland, forest land, rangeland, and other lands may require acceleration of funds and technical assistance, tax relief, and stabilization of rural income. Cost-sharing that extends beyond the present programs of technical assistance and conservation measures is needed. Some of these are established or can be established in the counties under programs of the Agricultural Stabilization and Conservation Service (ASCS). In any event, a basinwide program to implement the elements for land treatment is needed.

COSTS AND BENEFITS

Costs to implement the USDA program opportunities as shown in Table 8-2 are based on installation of the structural measures by year 2020. Project installation costs were computed for Economic Development and Environmental Quality.

Average annual costs, including operation and maintenance, are shown, as well as average annual benefits. Average annual benefits are confined to floodwater damage reduction and improved agricultural water management.

Construction costs for structural measures are based on 1975 prices, and benefits are based on 1975 current normalized prices.

The average annual cost for the structural measures included in the USDA program opportunities amounts to $5,515,600 which would produce average annual primary benefits of $7,267,000. This would result in an overall benefit-cost ratio of 1.3:1.0.

IMPACTS

General Environment

Installation of most plan elements will contribute to the overall improvement of environmental quality within the basin. Although losses will occur to certain types of natural habitat for wildlife, the result will be a general improvement in the environment for the basin residents.

Beneficial impacts from applied conservation practices will accrue on 200,700 acres by 2000. Adverse impacts will convert nearly 8,500 acres of terrestrial habitat to aquatic habitat and will affect approximately 400 acres of right-of-way along the channels to be modified.

Flooding, erosion, and sediment damages will be reduced. Revegetation, planting of trees, installation of terraces, woodland stand improvement, and other conservation practices will help improve the aesthetic quality of the landscape.

Water quality will be improved by the combined results of all practices which hold soil in place and reduce pollution.

Archeological and historical sites will be identified and preserved. Impetus is expected to be generated to guarantee the preservation of these areas and enhance the basin's environmental appeal.

The impacts on wildlife and fish habitat will affect the basin's total environment. Quality and diversity of all aspects of the natural environment will be a pleasing environment to basin residents. Implementation of the USDA program opportunities within the basin should help maintain a balance between these two environmental attributes as well as provide ways for basin residents to participate in activities involving the total environment.

It is anticipated that the works of improvement proposed in this plan will have significant impacts on the quality of the human environment. The long-term cumulative impacts of the projects in

the Red River Basin Above Denison Dam are as follows: The works of improvement, both land treatment and structural, will help contribute to conservation, development, and productive use of the soil, water, and related resources. The projects will allow the productivity of the resources to be sustained economically and indefinitely. The standard of living of the residents of the region will be improved through added income. The projects will restrict the use on the land needed for installation of the works of improvement. The vegetation will be destroyed on the land used to store water until displaced by sediment and will be temporarily disturbed on the land used to build the structural measures. This will adversely affect the wildlife in the immediate site areas. However, the overall habitat conditions are expected to become more favorable as a result of a more dependable food and water supply and better management techniques. A total of 8,500 acres of surface water which can be used for lake fisheries, waterfowl resting areas, etc., has been created by the projects either installed or approved for operation.

The commitment of labor, material resources, and energy required for construction will be irretrievable.

During detailed planning, the implementing Federal and/or State agencies should re-examine each water resource development project and make appropriate modifications to minimize and mitigate adverse impacts on the environment. This should include consideration of all resource values necessary for the orderly development of water and related land resources.

If the USDA program opportunities are not realized, anticipated economic and environmental benefits will be foregone. An increase in erosion rates, sedimentation, flood problems, and continued encroachment on ecologically sensitive areas will occur in the absence of positive resource planning.

Recreation

The opportunities for additional recreation activity-days that could be provided by seven multi-purpose watershed structures in Oklahoma are shown in Table 8-10.

These additional activity-days that will be provided include such activities as skiing, boating, fishing, camping, picnicking, swimming, hiking, and observing nature.

The activity-days provided by these multiple-purpose structures were not compared to the recreation needs shown in Chapter 7.

The program opportunities identified during this study provide no measures for meeting the recreational needs for Texas. These needs will have to be met through a coordinated effort of all levels of governmental agencies and must include the private sector. State, county and city parks can be expanded through Federal cost-share programs such as Resource Conservation and Development programs (RC&D).

Fish and Wildlife Resources

In general, fish and wildlife resources will fluctuate as available habitat is created or reduced. Present trends in habitat are expected to continue in a similar fashion through 2000. The early action projects will slightly decrease the amount of habitat. Project actions include the construction of 16 miles of channel modifications, 147 floodwater retarding structures, 32 multi-purpose structures, and the modification of 39 existing structures. These structures will reduce the terrestial habitat, and increase the aquatic resources.

Wildlife: Wildlife resources are expected to decline through 2000 as intensification of agricultural lands and urban sprawl reduce habitat. Reduction of flood damages due to project actions tends to promote conversion of rangeland and woodland to cropland and pasture resulting in reduced wildlife habitat. These indirect effects of project actions are expected to bring about the loss of 3,377 acres of woodland and 10,324 acres of rangeland in the protected flood plain of Oklahoma. In Texas the land use in the flood plain is expected to remain the same. There are 709 additional acres of woodland and 6,509 acres of rangeland habitat that will be inundated by the sediment pool of the proposed structures (direct effects), Table 8-4. In some watersheds woodland is sparse over the area in general and concentrated along streams. In these cases, the riparian woodland affected by project measures is far more critical and significant than in those watersheds where non-riparian woodland is more common.

Fisheries: The stream fisheries resources are expected to continue to decline as quality and quantity of stream habitat declines. Natural and manmade pollution and growing demands for industrial, municipal, and agricultural water, either directly from the stream or through impoundment of stream water, are the major factors causing the decline in habitat.

Stream habitat quantity and quality will be greatly reduced over the 16 miles of channel modification due to loss of pools, riffles, meanders, various types of bottom land habitat, changes in temperature, increased peak flows, and reduced

TABLE 8-4

Fish and Wildlife Habitat Changes
Due to USDA Project Developments

Habitat	Oklahoma Current	Oklahoma 2000	Oklahoma 2020	Texas Current	Texas 2000	Texas 2020	Basin Total Current	Basin Total 2000	Basin Total 2020
	---Acres---								
Forestland									
Future Without	768308	723242	707216	108323	108327	108327	876631	831569	815543
Future With									
Direct Change		-709	-1805		-	-		-709	-1805
Indirect Change		-3377	-5779		-	-		-3377	-5779
Total	768308	719156	699632	108323	108327	108327	876631	827483	807959
Rangeland									
Future Without	4174792	3914230	3838626	7994178	7898524	7797274	12168970	11812754	11635900
Future With									
Direct Change		-5550	-12659		-959	-959		-6509	-13618
Indirect Change		-10324	-14098		-	-		-10324	-14098
Total	4174792	3898356	3811869	7994178	7897565	7796315	12168970	11795921	11608184
Lake Fisheries Habitat									
Future Without	224249	224249	224249	210700	210700	210700	434949	434949	434949
Future With		+8000	+18200		+600	+600		+8600	+18800
Total	224249	232249	242449	210700	211300	211300	434949	443549	453749

Source: River Basin Staff, SCS

flow duration. The construction of impoundments, although reducing amount of stream habitat available at impoundment sites, should generally benefit downstream habitat by reducing sedimentation, reducing peak flows, and prolonging low flow duration. No upstream fish migration or significant stream sport fish habitat will be affected by stream impoundment.

Types III and IV wetlands were inventoried by the fish and wildlife workgroup during the course of this study on one of the feasible watersheds, Sweetwater Creek. Approximately 80 acres of these wetlands could be affected by project action. During actual project planning, the structures planned for this watershed should be placed or designed to minimize the adverse effects on these wetlands. Wetlands may also occur in other watersheds; these will be determined during watershed planning.

These impacts relate a general overview as to the effects project implementation could have on the biological environment.

A detailed inventory will be made for each watershed to properly analyze the effects these proposed projects would have on the terrestrial and aquatic ecosystems. The extent of mitigating the loss of biological resources, such as wetlands, riparian and stream habitat accrued during project implementation will be determined during this investigation.

Land Use

The major land use changes as projected over time are shown in Table 8-5. Changes over time without any project type developments are shown and these projected changes were made by extrapolating historical trends. Anticipated changes due to the planned project development are based on experienced changes in developed watersheds of similar characteristics. It is anticipated that with development of flood control projects on 19 watersheds with a total drainage area of 2.5 million acres and 200,000 acres of flood plain, there will be some agricultural land use intensification.

The net effect of the 17 watersheds in the Oklahoma portion of the basin will be increases in 12,800 acres of non-irrigated cropland, 2,100 acres of irrigated cropland, 3,400 acres of non-irrigated pasture, 1,600 acres of irrigated pasture, and decreases of 5,800 acres of forest land and 14,100 acres of range.

The production effects from 18,636 acres of supplemental irrigation from water stored in existing USDA structures plus

Table 8-5

Current and Projected Major Land Use Changes on Protected Soils Due to USDA Project Opportunities

Red River Basin Above Denison Dam (Oklahoma)

Land Use	Current	2000	2020
	Acres		
Cropland			
Without Development	3,438,500	3,468,000	3,464,700
With Watershed Project	3,438,500	3,477,000	3,479,600
Change Due to Project	0	9,000	14,900
Pastureland			
Without Project	960,700	1,125,000	1,145,100
With Project	960,700	1,129,700	1,150,164
Change Due to Project	0	4,700	5,000
Rangeland			
Without Project	4,174,800	3,914,200	3,838,600
With Project	4,174,800	3,903,900	3,824,500
Change Due to Project	0	-10,300	-14,100
Forest Land			
Without Project	768,308	723,200	707,200
With Project	768,308	719,900	701,400
Change Due to Project	0	3,300	-5,800

Source: SCS

those built by year 2000 are also shown, Table 8-6. The production effects of this added irrigation were not determined for year 2020.

The linear programming model used for determining the future without condition in Chapter 5 was also used in determining production with the USDA Program Opportunities.

Economic Impact

The added production resulting from decreased flooding in the Oklahoma portion of the basin provided about four percent of the needs (difference between OBERS E' and future without conditions) by 2000, see Table 8-6. Supplemental irrigation added another four percent. Thus USDA program opportunities could provide up to eight percent of the total production needs.

The added production will come about with a small shift in land use patterns. These land use changes do not have adverse environmental effects. In addition, they afford a reduction in risk and in the cost per unit of output. The increase in crop yields with projects in place leads to increased production with little if any increase in inputs.

The complexity of relationships that exist between various sectors of the local economy and how they relate to the region and the Nation make it difficult to quantify all of the effects likely to occur. The basin's economy is made up of the aggregate economic activity of all the residents. A change that occurs initially in one of the basic sectors (such as agriculture) will signal adjustments to take place in other sectors which will induce further changes and so on. When all of these changes are quantified in terms of employment and/or income, they are useful in measuring the impact of installing works of improvement.

First, the value of increased production was determined based upon current normalized prices. 1/ The added value of output from flood prevention in the USDA watersheds by 2000 is estimated at $2,537,800 plus an additional $1,989,300 from supplemental irrigation for a total of about $4.5 million annually.

By 2020 flood prevention alone can add about $4.3 million in crop production. These economic benefits will dispersed throughout the basin although some local areas will gain sooner than others. Also, since the added production does not displace agricultural output in areas outside of the basin, market prices will not be affected and the benefits are national in scope.

1/ Current Normalized Prices, U.S. Water Resources Council, October 1976.

TABLE 8-6

Production Effects Due to Project Development

Red River Basin Above Denison Dam
(Oklahoma)

Crop	Units	Quantities Needed 1/		USDA Programs Provides Through				Remaining Needs	
				Flood Protection		Supplemental Irrigation			
		2000	2020	2000	2020	2000	2020	2000	2020
Wheat	bu.	7,474,000	13,348,600	297,800	533,200	264,600	2/	6,911,600	2/
Grain Sorghum	bu.	2,196,400	3,187,600	87,500	127,300	77,800	2/	2,031,100	2/
Alfalfa	ton	58,400	196,700	2,300	7,900	2,100	2/	54,000	2/
Cotton	lb.	-	-	-	-	-	-	-	-
Peanuts	lb.	121,412,300	192,885,000	4,837,600	7,705,300	4,298,100	2/	112,276,600	2/

1/ Difference between OBERS E' projection and future without condition
2/ Not evaluated

Source: ERS

Coefficients developed for an input-output study for the State of Oklahoma and its sub-state planning areas are used to measure the income effects of the added production. A portion of the additional output ends up as income to households in the basin, Table 8-7. Flood protection and supplemental irrigation due to USDA program opportunities will add about $1.1 million annually to direct household incomes of farmers in the Oklahoma part of the basin by 2000. Using the appropriate multiplier, household income will expand to $2.1 million after farmers and suppliers of farm inputs spend and respend the original amount.

The total effect on labor resources of the basin due to added agricultural output involves other industries, too. Some industries will realize changes in output because they supply inputs directly to agriculture. These supplier industries, in turn, will require increased levels of inputs, some of which will be supplied by other industries in the basin. Each industr that undergoes a change in earnings pays those who supply labor to the production process. The impact on basin employment due to USDA opportunities is measured through use of regional gross output multipliers. 1/ These multipliers measure the economic effects that are triggered by added output from the agricultural industry.

By 2000, the added agricultural production from flood preventior can provide up to 128 man-years of employment, 2/ Table 8-7. Of this total, 48 man-years is direct farm employment and the remaining 80 man-years in other industries. Supplemental irrigation can affect employment opportunities in a similar way. 3/

1/ Regional Multipliers, Water Resources Council, January 1977.

2/ The increase in employment opportunities does not necessaril mean an increase in the number of employees. These added opportunities may be absorbed by underutilized labor resourc (see Chapter 5 for the incidence of underemployment in the Oklahoma part of the basin). The level of outmigration can also be affected by the increase in labor requirements.

3/ Gross output multipliers used in determining the added man-years of employment from implementation of USDA opportunitie may not be applicable in all types of resource development for the basin. Page two of the Regional Multiplier publicat (see Footnote 1) contains the following statements. "Certai limitations must be kept in mind, however. As with the type impact analysis when used if made of an I-O model, these mul pliers should not be used when the change under analysis is large that it will result in structural changes in the econo under study".

TABLE 8-7

Income and Employment Effects from
USDA Program Opportunities

Red River Basin Above Denison Dam

(Oklahoma)

Opportunity and Effect	Unit	2000	2020
Flood Prevention			
Value of Added Agricultural Output	$000	2,538	4,256
Increase in Household Income			
Direct	$000	639	1,072
Direct, Indirect, and Induced	$000	1,170	1,967
Employment			
Direct	Man-Year	48	48
Direct, Indirect, and Induced	Man-Year	128	129
Supplemental Irrigation			
Value of Added Agricultural Output	$000	1,989	NA
Increase in Household Income			
Direct	$000	506	NA
Direct, Indirect, and Induced	$000	946	NA
Employment			
Direct	Man-Year	38	NA
Direct, Indirect, and Induced	Man-Year	100	NA

Source: ERS

Local benefits can also accrue through the investment of non-local capital in resource developments. The Federal share of total cost for flood prevention and supplemental irrigation by 2000 is estimated at $25.8 million. If a 20-year period is required for project installation and Federal funds are provided in equal increments, this is equivalent to $1.3 million annually. This level of annual investment furnishes opportunity for 65 man-years of employment during the construction period.

Socio-economic problems of the basin were discussed earlier in Chapter 5. Development of the basin's resources can contribute to the alleviation of these problems. The end result of implementing USDA opportunities for flood prevention and supplemental irrigation will likely be a blend of adding a few dollars to income of basin residents, adding a few jobs and slightly reducing out-migration.

Opportunities for Increasing Agricultural Production

There are opportunities for increasing food and fiber production in the basin. Several of these opportunities such as flood prevention, irrigation, drainage, and land treatment were discussed earlier in this report. The agricultural output effects of implementing some of these methods through USDA programs are also shown earlier.

There is a potential for expanding agricultural production through increased use of fertilizer. Pesticides, herbicides, fungicides and related products may also aid in increasing production. Excessive quantities of these materials can result in adverse environmental effects. The output effects resulting from use of these products were not estimated because adequate data were not available to establish production functions for the various soil resource groups within the land resource areas or sub-state planning areas.

Additional agricultural output can be acquired through land use conversion. This means shifting land from one of the major uses such as cropland, pasture or range, and forest to another major use. For example, land that is grazed at the present can be converted to cropland. However, the output effects would be a transfer from AUM's of grazing to production units of other crops. The vegetation supported by some of the soils should remain as grass because of the adverse environmental effects that can follow disruption of protective ground cover. Thus only the soil resource groups with acceptable erosion rates and other tolerable limits of environmental effects should be considered for land use conversion.

A significant potential for increasing production on cropland through land use shift exists in the basin. For instance, the remaining needs in year 2000 for wheat, grain sorghum, alfalfa, and peanuts in the Oklahoma part of the basin are shown earlier in Table 8-6. It is estimated that these remaining needs can be appeased by shifting about 300,000 acres from range and pasture to cropland. These acres would come from more productive soil resource groups across the three sub-state planning areas. In order to satisfy these remaining needs, there will be tradeoff between grazing output and crop production. Approximately four to five percent of all animal units of grazing would be forfeited to achieve the desired production level of five major crops.

Effectiveness in Meeting Ojectives and Component Needs

Water and land resource problems of the basin resulted in study concerns as described in Chapter 3. These study concerns were then used to identify the specific components of the major objectives, Table 3-11.

Component needs were identified to meet these objectives in Chapter 7 and summarized in Table 7-10. These needs were quantified for each objective and are obtainable within the limits of the basin resources. There may be some problems relating to financial matters and expansion of some programs. The USDA programs would meet the objectives, as outlined, if the program elements are installed. The overall effectiveness to meet objectives depends on the effectiveness of the USDA program to meet the component needs.

The implementation of project and program measures are identified in Table 8-8. A summary of effectiveness is in the following explanation.

Flood Prevention: Currently there are 84 watersheds (32 in Oklahoma and 52 in Texas) in the basin that has no structural protection. Of this total 19 watersheds (17 in Oklahoma and 2 in Texas) can be planned and in operation by the year 2020 under the authority of PL 83-566. Structural measures on these 19 watersheds will provide protection to 194,000 acres (186,000 in Oklahoma and 8,000 in Texas).

Ten of the watersheds (8 in Oklahoma and 2 in Texas) can be in operation by the year 2000.

Approximately five percent of the total agricultural water needs (irrigation) for the Oklahoma portion of the basin can be met by the implementation of these measures. These will

TABLE 8-8

USDA Program Opportunity Effectiveness

Red River Basin Above Denison Dam

Component Needs	Units	Quantities Needed 2000 Oklahoma	Quantities Needed 2000 Texas	Quantities Needed 2020 Oklahoma	Quantities Needed 2020 Texas	USDA Programs 2000 Provides Oklahoma	USDA Programs 2000 Provides Texas	USDA Programs 2000 Remaining Oklahoma	USDA Programs 2000 Remaining Texas	USDA Programs 2020 Provides Oklahoma	USDA Programs 2020 Provides Texas	USDA Programs 2020 Remaining Oklahoma	USDA Programs 2020 Remaining Texas
Flood Damage Reduction													
Agriculture	1000 acres	186	8	186	8	78	8	108	0	186	0	0	0
Agriculture Water													
Irrigation	1000 ac.ft./yr.	475	1,283	1,154	1,943	28	0	447	1,283	61	0	1,093	1,943
Non-Agriculture Water													
Industry, rural urban, & utility	1000 ac.ft./yr.	14	-	29	-	3	-	11	-	4	-	25	-
Recreation	1000 activity days	16.4	1/ 51,968	19.2	1/ 95,292	185	0	16.4	51,968	323	0	19.2	95,292
Erosion & Sedimentation Damage Reduction													
Wind	1000 acres	35	81	89	162	4	5	31	76	4	5	85	157
Sheet	1000 gross tons	3,841	2,360	9,004	10,834	617	134	3,224	2,226	667	134	8,337	10,700
Gully	1000 gross tons	2,608	980	2,913	1,903	39	53	2,569	927	35	53	2,878	1,850
Streambank	1000 gross tons	1,785	685	2,005	1,374	37	32	1,748	653	40	32	1,965	1,342
Roadside	1000 gross tons	1,431	156	1,599	414	38	16	1,393	140	40	16	1,558	398
Flood plain scour	1000 acres	26	12	41	25	12	1	14	11	14	1	27	24
Overbank deposition	1000 acres	41	27	66	55	20	2	21	25	24	2	42	53
Lake Texoma	1000 gross tons	1,359	1,201	2,446	2,854	693	100	666	1,101	891	100	1,555	2,754

1/ Does not reflect local community needs

Source: SCS

reduce the needs for 2020 from 1,154,000 acre-feet per year to 1,093,000 acre-feet per year.

The Total Basin: Nonagricultural water needs for Oklahoma for year 2020 may be reduced by 18 percent by implementation of these measures. These will reduce needs from 29,000 acre-feet per year to 25,000 acre-feet per year.

The implementation of measures will provide 323,300 activity-days of recreation at the local level. These are for small local needs, which are not identified in the basin needs. Therefore, a reduction in needs for the total basin is not shown.

The entire Oklahoma portion of the basin will realize the effectiveness of the applied land stabilization and land treatment measures included in the applied project measures. The reduction in percent by year 2020 is as follows: wind erosion 30; sheet erosion 45; gully erosion 53; streambank erosion 32; roadside erosion 19; flood plain scour 58; overbank deposition 49; and sediment to Texoma 69.

The implementation of the potential project measures within the Texas portion of the basin will have very little effect on the total erosion and sedimentation conditions by the year 2020.

IMPLEMENTATION PROGRAMS

General

The program is a mix of elements from the major objectives with implementation opportunities for individual plan elements through a variety of Federal, State, and local programs. The priorities and schedule for installation of various elements will depend upon the willingness of local people to undertake organizational efforts necessary for project action. Technical and financial assistance for most elements can be obtained through existing programs of local, State, and Federal agencies. Some elements can only be installed with significant increases in levels of funding or additional local, State, or Federal legislation, and program authorities may be needed. The kind and amount of measures that can be implemented under USDA programs and other programs are identified in Table 8-9.

Floodwater Damage Reduction

The USDA programs to implement USDA program opportunity elements to reduce flood damages are the small watershed program (PL 83-566) the Great Plains Conservation Program (PL 84-1021),

Table 8-9

Elements and Program Means for Implementation

Red River Basin Above Denison Dam

Elements	U. S. Department of Agriculture Programs	Other than USDA Programs
Resource Management Systems	ACP, GPCP, PL 74-46, PL 83-566, PL 78-534, RC&D	Texas Forest Service, Oklahoma Forestry Division
Flood Damage Reduction Channel Modification	ACP, PL 74-46, PL 83-566, PL 78-534, RC&D	National Weather Service, USGS, COE, HUD-FIA, FmHA
Floodwater Retarding Structures	PL 83-566, PL 78-534, RC&D	National Weather Service, USGS, COE, HUD-FIA, FmHA
Non Structural	PL 83-566, PL 78-534, RC&D	National Weather Service, USGS, COE, HUD-FIA, FmHA
Irrigation Water 1/		Bureau of Reclamation, State River Authority, Corps of Engineers
Erosion & Sedimentation Damage Reduction Sheet	ACP, PL 74-46, GPCP	
Overbank Deposition	ACP, PL 74-46, PL 83-566, PL 78-534, RC&D, GPCP	PL 92-500
Gully	ACP, PL 74-46, PL 83-566, PL 78-534, RC&D, GPCP	PL 92-500
Streambank	ACP, PL 74-46, PL 83-566, PL 78-534, RC&D, GPCP	PL 92-500
Roadside	ACP, PL 74-46, PL 83-566, PL 78-534, RC&D, GPCP	PL 92-500
Site Preservation Archeological		USDI NPS, Texas Archeological Society Oklahoma Archeological Society
Historical		USDI NPS, Texas Historical Commission Oklahoma Historical Commission
Increased Recreation Parks		USDI, NPS
Camping	RC&D, FS, PL 83-566, PL 78-534	USDI, TPWD, NPS
Picnicking	RC&D, FS, PL 83-566, PL 78-534	USDI, TPWD
Playground	RC&D	TPWD
Trails (Combined)	RC&D, FS, PL 83-566, PL 78-534	TPWD, NPS
Fishing Piers	RC&D, PL 83-566, PL 78-534	USDI
Watersports	RC&D, PL 83-566, PL 78-534	USDI
Boat Ramps	RC&D, FS, PL 83-566, PL 78-534	USDI, TPWD
Fish and Wildlife Habitat Improvement & Increase Water Impoundments	PL 83-566, PL 78-534, ACP, RC&D, PL 74-46, FS	USDI, Dingell-Johnson Act, Duck Stamp Act, Pittman-Robertson Act TPWD, Oklahoma Game and Fish Commission

1/ State Water Plan

Source: River Basin Staff, USDA

and the Resource Conservation and Development program (PL 87-703). Potential watershed projects are identified on Plate 8-1. The Soil Conservation Service has primary responsibility for administering PL 83-566 and the RC&D program. Local sponsorship and public participation is required before planning can be initiated.

Request for additional water supplies, such as recreation, municipal, industrial, and irrigation should be made through the conservation district offices where the water needs exist. These requests would be forwarded to the Soil Conservation Service field and area offices involved. Requests may include adding other sponsors to present plans when needed. Irrigation associations for sub-basins or for other area groupings would facilitate development of a more comprehensive supplemental plan for irrigation water supplies. Water rights and permits would need to be obtained from the State's Water Rights Agency.

Section 193 of PL 94-587, the Federal Water Resources Development Act of 1976 authorizes the Secretary of Commerce, appropriate Federal, State, and local agencies to study the depletion of the natural resources of the regions of the States of Colorado, Kansas, New Mexico, Oklahoma, Texas, and Nebraska presently utilizing the declining water resources of the Ogallala Aquifer, and develop plans to increase water supplies to the area and report to Congress with recommendations for further congressional action. The feasibility of various alternatives to provide adequate water supplies to the region will be examined. The interim report with recommendations shall be transmitted to Congress by October 1, 1978 with the final report due in Congress by July 1, 1980.

Land Stabilization: This includes plan elements of critical area stabilization and land management.

The critical area stabilization measures included can be accomplished by expanding to the remainder of the basin the type of critical area stabilization measures that have been planned on the PL 78-534 project in Oklahoma. Authorization would be needed to implement this action through the Soil Conservation Service and its field offices with basic plans to identify needs for individual watersheds or sub-basins. Emphasis should be placed on watersheds or sub-basins which contribute the most to non-point pollution.

The land management measures should be the same type that the Soil Conservation Service provides technical assistance for in normal district operations. Emphasis should be placed on accelerating land treatment practices on early action watersheds to reduce sources of sediment and to enhance the structural

measures planned for flood control, municipal and industrial use, irrigation use and recreation developments. Added emphasis to land treatment and critical area stabilization could prolong the life of present planned and built structural measures on the planned PL 83-566 watersheds.

SUMMARY OF ACCOUNT

As required by the Principles and Standards, the beneficial and adverse effects of USDA program opportunities are displayed in Table 8-10. The data are presented for each State and for the basin.

Major planning objectives outlined in Chapter 3 are adjusted in this chapter and the Summary to reflect procedural adjustments described in Chapter 2 and most recent directive concerning the division of national and regional benefits. These chapters presented studied information related to program opportunities implementable by the U. S. Department of Agriculture if authorization and funding are available. Specific components or elements are thus accounted for under Economic Development (ED) and Environmental Quality (EQ). The delineation between national and regional development accounts has been omitted. ED components will enhance economic development by increasing the value of goods and services and improving economic efficiency. EQ components will enhance environmental quality by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.

The classification of a component or component needs as ED or EQ does not preclude the use of elements of that component in planning toward either objective.

LEGEND

NUMBER	WATERSHED	TEXAS (ACRES)	NEW MEXICO (ACRES)	OKLAHOMA (ACRES)
1	Palo Duro Creek	650,800	9,963	
2	Tierra Blanca Creek	352,100	209,500	
3	Frio Draw	208,900	205,137	
4	Lower Tierra Blanca Creek	251,700		
5	Tule Creek	843,100		
6	Upper Prairie Dog Town Fork	956,400		
7	Quitaque Creek	369,600		
8	Mulberry Creek	338,300		
9	Lakeview	151,700		
10	Little Red River	223,900		
11	Kent Creek	27,000		
12	North Pease River	605,500		
13	Dutehman Creek	51,200		
14	Afton Area	53,100		
15	MeClellan Creek	222,400		
16	Salt Fork Red River	994,900		181,408
17	Indian Creek	53,000		
18	Middle Pease River	429,200		
19	Tongue River	323,300		
20	Upper North Wiehita River	257,800		
21	South Wichita River	465,800		
22	Upper Washita River	288,200		170,290
23	Sweetwater Creek	200,000		
24	North Fork Red River	515,700		
25	Buck Creek	184,300		8,454
26	Lower Prairie Dog Town Fork	355,300		
27	Middle Fork Wiehita River	111,200		
28	Lower Sweetwater Creek	81,800		58,112
29	Elm Creek	227,000		196,269
30	Lebos Creek	40,200		214,790
31	North Hardeman County Laterals	42,100		
32	Grosebeek Creek	239,400		
33	Wanderers Creek	148,800		
34	Lower Pease River	516,000		
35	Lake Kemp	502,500		
36	Salt Creek	69,100		
37	East Wilharger County Laterals	41,500		
38	Big Beaver Creek	431,200		
39	Lake Diversion	83,800		
40	Upper Little Wiehita River	520,600		
41	China Creek	38,500		
42	Gilbert Creek	104,400		
43	Pond Creek	27,000		
44	Wiehita Valley	292,700		
45	Lower Wiehita River	93,200		
46	Lower Little Wiehita River	429,000		
47	Clay County Laterals	49,900		
48	Little Beaver Creek	28,900		
49	Belknap Creek	123,600		
50	Montague County West Laterals	104,300		
51	Farmers Creek	65,500		
52	Montague County East Laterals	43,800		
53	Mountain Creek	23,400		
54	Cooke County West Laterals	101,500		
55	Cooke County East Laterals	58,500		
56	Big Mineral Arm	180,100		
57	Little Mineral Arm	32,700		
58	Broken Leg			10,523
59	Sergeant Major			19,684
60	Dead Indian Wildhorse			64,862
61	Nine Mile			54,315
62	Beaver Dam			27,620
63	Sandstone			65,013
64	Big Kiowa			25,922
65	Whiteshield			17,384
66	Quartermaster			123,377
67	Panther			47,216
68	Butler Laterals			47,114
69	Soldier			44,748
70	Turkey			47,320
71	Barnitz			178,674
72	Beaver			56,605
73	South Clinton Laterals			50,817
74	Bear			53,605
75	Gyp			71,828
76	Boggy			74,043
77	Cavalry			69,952
[illegible]	[illegible]			46,394
[illegible]	Rainy Mountain			209,959
80	Saddle Mountain			72,420
81	Cowden Laterals			81,884

NUMBER	WATERSHED	TEXAS (ACRES)	NEW MEXICO (ACRES)	OKLAHOMA (ACRES)
82	Fort Cobb Laterals			77,520
83	Cobb			207,161
84	Cobb (Fast Runner)			7,735
85	Sugar			189,076
86	Tonkawa			30,640
87	Delaware			36,879
88	Spring			53,492
89	Ionine			54,521
90	Salt			63,265
91	Bitter			73,243
92	Line			50,516
93	Little Washita			150,808
94	Winter			61,722
95	Roaring			67,995
96	Colbert			14,812
97	Bear Hybarger			23,357
98	Criner			42,480
99	Round			46,702
100	Maysville Laterals			44,234
101	Finn			58,636
102	Wayne			20,574
103	Owl			19,545
104	Washington			17,488
105	Peavine			38,645
106	Cherokee Sandy			46,291
107	Rush			191,557
108	Kiekapoo Sandy			41,662
109	Wildhorse			427,943
110	Chigley Sandy			29,349
111	Roek			109,043
112	Caddo			263,349
113	Big Canyon			24,689
114	Mannsville Laterals			56,064
115	Oil			40,762
116	Mill			77,739
117	Pennington			82,605
118	Big Sandy			40,119
119	Glasses			47,731
120	West Laterals of Texoma			37,033
121	East Laterals of Texoma			38,062
122	North Texoma Laterals			184,589
123	Hiekory			233,459
124	Lower Bayou			95,488
125	Upper Bayou			119,680
126	Lower Mud			288,840
127	Upper Mud			181,318
128	Fleetwood and Red			143,040
129	Jefferson Laterals			33,350
130	Whiskey			46,406
131	Rabbit			58,560
132	Blue			187,540
133	Lower Beaver (above Waurika Res.)			60,224
134	Lower Beaver (below Waurika Res.)			65,517
135	Cow			123,667
136	Little Beaver			125,018
137	Big Beaver			174,010
138	Lower East Cache			245,139
139	Squaw			7,942
140	Upper East Caehe			287,002
141	Lower West Caehe			90,790
142	Upper West Caehe			210,137
143	Lower Deep Red Run			112,627
144	Jaek			45,709
145	Middle Deep Red Run			186,688
146	Deep Red Run-Coffin			58,598
147	Lower North Fork			229,850
148	Lower North Fork Tributaries			75,712
149	Otter			173,958
150	Lower Elk			163,923
151	Upper Elk			250,265
152	Middle North Fork			336,134
153	Timber			41,619
154	Upper North Fork			128,410
155	Tri-County Turkey			196,403
156	Bitter			70,035
157	Gypsum			95,610
158	Lower Elm Fork			164,000
	Lake Texoma 1/			56,987
	TOTAL	14,225,400	424,600	10,743,890

1/ Area of Lake Texoma in Washita Basin

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

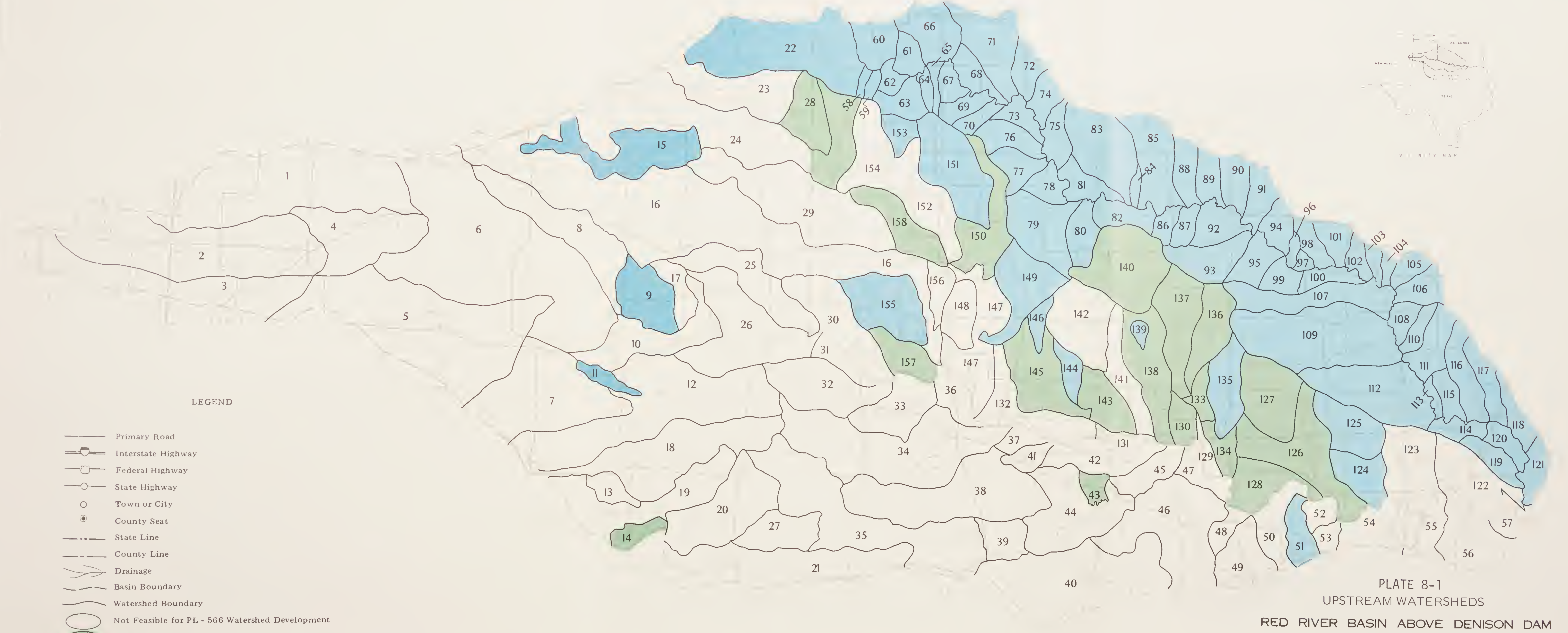


PLATE 8-1
UPSTREAM WATERSHEDS
RED RIVER BASIN ABOVE DENISON DAM
NEW MEXICO, TEXAS AND OKLAHOMA

APPROXIMATE SCALE - MILES

Base compiled from USGS 1:500,000 Quadrangles.
Lambert Conformal Conic Projection.

LEGEND

- Primary Road
- Interstate Highway
- Federal Highway
- State Highway
- Town or City
- County Seat
- State Line
- County Line
- Drainage
- Basin Boundary
- Watershed Boundary
- Not Feasible for PL - 566 Watershed Development
- Potential for PL - 566 Watershed Development
- PL - 566 Watershed Work Plan Development (Including Authorized Washita River)

NOTE: No. 28, Lower Sweetwater Creek, is Potential for PL-566 Watershed Development When Considered Jointly With Oklahoma Portion.

SOURCE: Data compiled by SCS River Basin Planning Staff.

MAY 1976 4-R-35533
APRIL 1974 4-R-32846-1

USDA-SCS-FORT WORTH, TEXAS 1976

TABLE 8-10

Program Opportunities
Economic Development Account

Red River Basin Above Denison Dam
(2000)

Components	Oklahoma	Texas	Basin Total
Beneficial Effects			
A. Employment augmentation due to increased agricultural output	Average Annual Man-Years		
1. Floodwater damage reduction	128	-	128
2. Supplemental irrigation	100	-	100
B. Employment augmentation during construction period	65	8	73
C. The value to users of increased output of goods and services	--Average Annual $000--		
1. Flood prevention	2,143	209	2,352
2. Nonagricultural water management	165	-	165
3. Agricultural water management	1,122	-	1,122
4. Recreation	231	1	232
Total	3,661	210	3,871
Adverse Effects			
A. Value of resources required for single and multi-purpose floodwater retarding structures and channel improvement			
1. Project installation and administration	2,681	109	2,790
2. OM&R	126	3	129
Total	2,807	112	2,919
Net Beneficial Effects	854	98	952

Source: River Basin Staff, USDA

Table 8-10 (cont'd)

Program Opportunities
Environmental Quality Account

Red River Basin Above Denison Dam

Components	Measures of Effects	Unit	Oklahoma	Texas	Basin Total
Beneficial and adverse effects					
A. Areas of natural beauty	1. Create water surface	Acres	8,000	483	8,483
	2. Convert natural channel to man made	Miles	16	0	16
	3. Inundate and alter land use by single and multi-purpose floodwater retarding structures				
	a. Pasture	Acres	830	0	830
	b. Cropland	Acres	830	0	830
	c. Rangeland	Acres	5,550	959	6,509
	d. Wooded		790	0	790
	4. Plant channel banks and rights-of-way to vegetation	Acres	390	0	390
	5. Eliminate woody riparian vegetation	Acres	4,170	0	4,170
	6. Convert land to stream channel	Acres	50	0	50
	7. Provide vegetation to critical eroded areas	Acres	11,600	0	11,600
B. Quality considerations of water and land resources	1. Reduce sheet erosion all sources	Gross Tons	667,000	133,600	800,600
	2. Reduce scour damage on flood plains	Acres	14,200	450	14,650
	3. Reduce outbank deposition on flood plains	Acres	23,800	1,500	25,300
	4. Reduce sediment delivered to Texoma	Tons	891,200	100,100	991,300
	5. Provide good quality municipal and industrial water	Ac Ft/Yr	2,900	0	
C. Biological resources and selected ecosystems	1. Improve wildlife habitat for ground nesting birds by reductions in flood frequency from floodwater retarding structures	Acres	78,000	13,812	91,812
	2. Create additional surface acres of water (floodwater retarding structures)	Acres	8,000	483	8,483
	3. Loss of woody riparian habitat		4,170	0	4,170
	4. Reseed disturbed areas to vegetation	Acres	1,400	476	1,876
	5. Inundate or disturbs wetlands	Acres	0	80	80
D. Archeological resources	1. Preserve and protect archeological sites	No.	850	1,077	1,927
	2. Preserve and protect historical sites	No.	20	108	128
	3. Inventory additional archeological sites	No.	950	50	1,000
E. Irreversible or irretrievable commitments	1. Conversion of agricultural land to dams, spillways, and sediment pools	Acres	9,400	959	10,359
	2. Conversion of land to stream channels	Acres	50	0	50
	3. Loss of wetland		0	80	80

Source: River Basin Staff, USDA

TABLE 8-10 (Cont'd)

Social Well-Being Account

Red River Basin Above Denison Dam

Components	Beneficial and Adverse Effects
1. Personal income increase	1. Increased operator efficiencies will be beneficial to a broad base of farming enterprises. 2. Operational cost savings and increased yields will assist rural farm families to achieve OBERs projected per capita income levels.
2. Employment	1. Income and employment increases anticipate both increased employment of underemployed and unemployed labor resources at minimum to medium scale. 2. Employment of persons directly and indirectly associated with program opportunities affects a broad range of agribusiness activities.
3. Health and safety	1. Increased use of natural resources at potential levels and at higher and better uses. 2. Increased food and fiber output, economic stability and potential for semi-skilled employment. 3. Increased safety of outdoor leisure in planned, natural environment.
4. Rural opportunities	1. Stabilizes rural economy and rural living in areas of productivity improvement. 2. Increases opportunity for profit in the rural areas.

Source: River Basin Staff, USDA

BIBLIOGRAPHY

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Barnes, Virgil E., Project Director. Geologic Atlas of Texas. Bureau of Economic Geology, the University of Texas at Austin.

Bonnen, C. A. and C. L. Godfrey. Crop Yields and Livestock Feeding Efficiencies for Texas 1975 and 2010. Texas Agricultural Experiment Station, College Station, Texas, July 29, 1960.

Dallas Morning News, Texas Almanac for various years.

Department of Pollution Control. Oklahoma Pollution Control Coordinating Board. Water Quality Management Plan, Upper Red River Basin.

Ellison, Samuel P., Jr. Sulphur in Texas. Bureau of Economic Geology, The University of Texas at Austin, 1971.

Fisher, W. L., L. F. Brown, Jr., Alan J. Scott, and J. H. McGowen. Delta Systems in the Exploration for Oil and Gas. Bureau of Economic Geology, The University of Texas at Austin, 1969.

Forestry Division of the Oklahoma Department of Agriculture. Forest Fire Statistics, 1975.

Gould, F. W. Texas Plants - A Check List and Ecological Summary. The Agricultural and Mechanical College of Texas, Texas Agricultural Experiment Station, 1962, pp. 112.

Grubb, Herbert W. The Structure of the Texas Economy. Office of the Governor, State of Texas, Volume 1 and Volume 2.

King, Horace Williams. Handbook of Hydraulics. McGraw-Hill Book Company, 1954.

Lanier, Ray S., and Michael J. Skinner. Some Notes on the Use of Soil Resource Group Information in USDA Type IV Studies. Southwest Resource Group, National Resource Economic Division, Berkley, 1973, pp. 19.

Oklahoma Department of Wildlife Conservation, Fisheries Research Lab. Creel Survey and Standing Crop Census of Oklahoma Reservoirs and Department Lakes, unpublished.

Oklahoma Department of Wildlife Conservation, Fisheries Research Lab. Stream Inventory, unpublished.

Oklahoma Department of Wildlife Conservation "Preliminary Estimates of Lands and Waters Needed for Public Hunting and Fishing in Oklahoma". Administrative Planning Report No. 7, 1967, unpublished.

Oklahoma Employment Security Commission. "Oklahoma Population Projections".

Oklahoma Geological Survey. "Ground Water Reservoirs in Oklahoma".

Oklahoma Industrial Development and Park Department and Bureau of Outdoor Recreation. "Oklahoma Outdoor Recreation Demand Study".

Oklahoma State University, Department of Agricultural Economics. Computer printouts of annual crop and livestock data from Oklahoma Department of Agriculture and U. S. Department of Agriculture.

Oklahoma State University, Department of Economics. Computer printouts of County Building Block data for selected Oklahoma counties.

Oklahoma State University, Department of Agricultural Economics and Cooperative Extension Service. Crop and Livestock Budgets for various years.

Oklahoma State University, Department of Agricultural Economics and Cooperative Extension Service. Custom Rates for Summer and Fall Jobs.

Oklahoma State University, Department of Agricultural Economics and Cooperative Extension Service. Custom Rates for Tillage and Spring Jobs.

Oklahoma State University. Irrigation Surveys for various years in Oklahoma as prepared by Delbert Schwab, Extension Irrigation Specialist.

Oklahoma State University, Research Foundation. Basic Data and Projections for the Oklahoma Economy by Planning District, July 1973, prepared for the Ozark Regional Commission.

Oklahoma Water Resources Board. "Appraisal of the Water and Related Land Resources of Oklahoma", Regions I, II, III, and IV.

Ozark Regional Commission. Projections and Analyses of the Economies of Sub-state Planning Districts in Oklahoma, Fiscal Year 1975.

Perrin, John, and Herbert W. Grubb. Population Projections for Texas Counties 1975 to 1990. Office of the Governor, State of Texas, October 1, 1975.

Schmedemann, Ivan W. Contributions to the U. S. Economy from Recreational Development in the Great Plains. Proceedings, Resource Economic Committee, Great Plains Agricultural Council, GPAC 49, Oklahoma Agricultural Experiment Station, 1970.

Schmedemann, Ivan W., and John G. McNeely. The Impact of Recreation on Local Economies. Texas Agricultural Experiment Station, TA-6076, 1967.

Sellards, E. H., W. S. Adkins, and F. B. Plummer. The Geology of Texas, Volume 1, "Stratigraphy", The University of Texas at Austin, 1932.

Texas A&M University and Texas Agricultural Extension Service. Crop and Livestock Budgets for various years.

Texas Department of Agriculture and U. S. Department of Agriculture. Texas County Statistics, 1973.

Texas Forest Service. Forest Fire Statistics, 1974.

Texas Forest Service. Forest Fire Statistics, 1975.

Texas Highway Department. County General Highway Map.

Texas Highway Department. Texas-Land of Contrast.

Texas Organization of Endangered Species. Plant Classification, 1975.

Texas Parks and Wildlife Department, Comprehensive Planning Branch. Unpublished data, County Inventory of Recreational Facilities, Austin, 1969.

Texas Parks and Wildlife Department, Comprehensive Planning Branch. A Statewide Recreation Information System, February 1974.

Texas Parks and Wildlife Department, Comprehensive Planning Branch. Texas Outdoor Recreation Plan. All Volumes, 1975.

Texas Parks and Wildlife Department, Comprehensive Planning Branch. Texas Outdoor Recreation Plan, "Techniques of Analysis", Preliminary Draft, July 1974.

Texas Parks and Wildlife Department, Comprehensive Planning Branch. Texas Outdoor Recreation Plan. Unpublished data, 1975.

Texas Soil and Water Conservation Needs Committee. Conservation Needs Inventory. Texas, 1970.

Texas Water Development Board. Estimated Monthly Runoff System, "Computer Program WD 8900", 1976.

Texas Water Development Board. Importance of Irrigation Water to the Economy of the Texas High Plains, Report 11, January 1966, prepared by Herbert W. Grubb.

Texas Water Development Board. Inventories of Irrigation in Texas 1958, 1964, and 1969, Report 127, May 1971.

Texas Water Development Board. Inventories of Irrigation in Texas 1958, 1964, 1969, and 1974, Report 166, October 1975.

Texas Water Development Board. Population Projections, December 1972.

Texas Water Development Board. The Texas Water Plan - Summary, November 1968.

Texas Water Development Board. Update System, "Monthly Reservoir Evaporation Rates for Texas", Report 64, October 1967.

University of Oklahoma, Bureau of Business and Economic Research. Statistical Abstract of Oklahoma, 1972, May 1973.

U. S. Army Corps of Engineers. Hydraulic Tables, Second Edition. U. S. Government Printing Office, Washington, D. C., 1944.

U. S. Department of Agriculture, Economic Research Service, Commodity Economics Division. Firm Enterprise Data System, Farm and Ranch Budgets, for selected production areas in Oklahoma and Texas.

U. S. Department of Agriculture, Economic Research Service. Net Migration of the Population, 1950-1960, By Age, Sex, and Color, Volume 1, Part 5, May 1965.

U. S. Department of Agriculture. Oklahoma Conservation Needs Inventory, March 1970.

USDA. Agricultural Statistics 1974.

USDA, Forest Service, SA, S&PF. Computerized Hydrologic Analysis and Output Systems, 1975.

USDA, Forest Service (in cooperation with Stephen F. Austin University). Special Report on Vegetative Cover (by SKY-LAB Satellite), 1975.

USDA, Forest Service. The Outlook for Timber in the U. S., 1973.

USDA. Recreation Participation, Preferences and Community at Lake El Reno, Oklahoma. In cooperation with Missouri University, 1973.

USDA. Selected Historical, Social, and Demographic Information, May 1974.

USDA, Soil Conservation Service. Economic Guide for Watershed Protection and Flood Prevention, March 10, 1964.

USDA, Soil Conservation Service. E&WP, Technical Guide 40, February 26, 1971.

USDA, Soil Conservation Service. National Engineering Handbook, Section 4, Hydrology, 1964.

USDA, Soil Conservation Service. National Engineering Handbook, Section 5, Hydraulics, 1950.

USDA, Soil Conservation Service. Special Report on Fish and Wildlife Resources, Red River Basin Above Denison Dam, Texas and New Mexico, January 1976.

USDA, Soil Conservation Service. Special Report on Outdoor Recreation Resources, Red River Basin Above Denison Dam, Texas, unpublished.

U. S. Department of Commerce. Area Measurement Reports, 1960.

U. S. Department of Commerce, National Oceanic and Atmospheric Administration. "Climatological Data", Oklahoma.

U. S. Department of Commerce, National Oceanic and Atmospheric Administration. Environmental Weather Bureau Technical Paper 40, "Rainfall Frequency Atlas of the U. S.", September 1961.

U. S. Department of Commerce, National Weather Service. *Monthy Climatological Data.*

U. S. Department of Commerce, Office of Business Economics. Income, Employment, and Earnings computer printouts for various counties and county groups of the Red River Basin Above Denison Dam.

U. S. Department of Commerce reports for various years:
Census of Agriculture
Census of Population
Census of Housing
Census of Mineral Industries
Census of Manufacturers
County-City Data Books

U. S. Department of the Interior, Geological Survey. Flood Characteristics of Oklahoma Streams.

U. S. Department of the Interior, Geological Survey. Water Resource Data for Oklahoma, Part I - "Surface Water Records", Part 2 - "Water Quality Records".

USDI, Bureau of Mines. *Mineral Yearbook 1969.* Volume 3, "Area Reports: Domestic", U. S. Government Printing Office, Washington, D. C., 1970.

USDI, Fish and Wildlife Service. *County Inventory Data of Wetlands in Texas,* Internal Data. Fort Worth Regional Office, Texas, 1954.

USDI, Fish and Wildlife Service. *Wetlands of the U. S.,* Circular 39, U. S. Government Printing Office, Washington, D. C., 1971.

USDI. *Outdoor Receation Space Standards.* U. S. Government Printing Office, Washington, D. C., 1970.

U. S. Department of Labor, Manpower Administration. Computer printout summaries of the 1970 Census of Population.

USGS. *Quad Sheets.*

U. S. Water Resources Council. *Agricultural Price Standards, Guidelines 2,* October 1976.

U. S. Water Resources Council. *Guideline Agricultural Price Standards for Water and Land Resources Planning,* October 1974.

U. S. Water Resources Council. 1972 OBERS Projections, Series E' Population Supplement, Agricultural Projections, Volumes 1, 3, and 4, May 1975.

U. S. Water Resources Council. 1972 OBERS Projections, Volumes 1-7, April 1974.

U. S. Water Resources Council. Regional Multipliers, Guideline 5, January 1977.

Voelker, Stanley W., Population Change and Net Migration by Counties in the Great Plains States, 1960-1970, Great Plains Council Publication No. 52, June 1971.

Williams, J. R. and W. V. La Seur. Water Yield Model Using SCS Curve Numbers, September 1976.